Department of Energy

ROCKY FLATS FIELD OFFICE
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OCT 0 1 2003

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Dear Mr. Gunderson and Mr. Rehder:

An aquatic monitoring program was initiated by the Department of Energy in the summer of 2001 to document resident aquatic communities and habitat conditions in the three drainages at the Rocky Flats Environmental Technology Site (Site). Biological monitoring was performed at a total of eleven representative sample locations in the Walnut, Woman, and Rock Creek drainages. The monitoring program included fish and benthic macroinvertebrate sampling and an intensive physical habitat assessment at all stations to document conditions for supporting aquatic life. The U.S. Fish and Wildlife Service provided informal comments during the initial stages of the program.

The drought conditions in 2002 adversely affected stream flow conditions in all drainages at the Site. Some streams were dry at several sampling locations, which limited the extent of biological and habitat monitoring conducted during 2002. The 2002 monitoring results document habitat conditions and the status of aquatic communities in drainages at the Site during extremely low water years under existing flow regimes.

Enclosed for your information is one copy of the report entitled "Results of the Aquatic Monitoring Program in Streams at the Rocky Flats Site, Golden, Colorado 2001-2002". The report documents the results of the aquatic monitoring program at the Site for Calendar Years 2001 and 2002 and was prepared by Aquatics Associates for the U.S. Department of Energy, Rocky Flats Field Office. If you any questions, please contact John Stover at 303-966-9735 or John Rampe at 303-966-6246.

Sincerely,

Joseph A. Legare, Assistant Manager
for Environment and Stewardship

Enclosure

ADMIN RECORD

BZ-A-000922

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OCT 0 1 2003

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RESULTS OF THE AQUATIC MONITORING PROGRAM IN STREAMS AT THE ROCKY FLATS SITE, GOLDEN, COLORADO 2001-2002

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RESULTS OF THE AQUATIC MONITORING PROGRAM IN STREAMS AT THE ROCKY FLATS SITE, GOLDEN, COLORADO 2001-2002

May 2003

Prepared for:

U. S. Department of Energy
Rocky Flats Field Office
Golden, Colorado

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EXECUTIVE SUMMMARY

An aquatic monitoring program in streams draining the Rocky Flats Environmental Technology Site was initiated in the summer 2001 to characterize the existing aquatic communities (fish and macroinvertebrates) and physical habitat conditions in the Walnut, Woman, and Rock Creek drainages. The purpose of this program is to provide a baseline for monitoring the potential influences of site closure activities, which will be ongoing through 2006, and may also be used as a reference for the post-closure period. Monitoring results for the 2001-2002 period are presented in this report, with comparisons to previous studies at Rocky Flats, upper Big Dry Creek, and other relevant published literature.

All of the streams at Rocky Flats are flow limited. While perennial flows are typically in the upper reaches of all three drainages, flows diminish considerably in downstream reaches where the streams become largely intermittent. Flow regimes, however, are different in the Walnut Creek drainage in areas downstream from South Walnut Creek. Between Ponds B-3 and B-5, the stream is effluent-dominated and discharges are relatively stable, whereas flows are discharge-dependent in reaches downstream from the terminal ponds (Pond A-4 on North Walnut Creek and Pond B-5 on South Walnut Creek) with releases occurring at 4 to 6-week intervals for durations of 10-15 days. When pond discharges are not occurring, the stream channel is typically dry, except when precipitation events are sufficient to provide adequate flow. In Woman Creek, in areas downstream from Pond C-2, pond releases can also occur, but happen on a considerably less frequent basis. Such natural and anthropogenic hydrologic regimes significantly influence habitat quality for aquatic life. In the upper reaches of Walnut, Woman, and Rock Creeks where flows are perennial, habitat assessment scores were generally highest indicating overall better habitat quality. Aside from the obvious flow limitations in all drainages, in the effluent-dominated reach of South Walnut Creek and the discharge-dependent lower section of Walnut Creek, bank erosion which results in poor bank stability and sediment inputs to the stream is the main problem that negatively affects physical habitat and aquatic life. Stream bank erosion is further aggravated by the periodic discharges from the terminal ponds.

Fish abundance and distribution in these streams is severely limited due to the obvious lack of permanent water. Fish were only collected at seven of the study sites, and only three species were collected. A naturally self-sustaining population of fathead minnows was found at site WC3 in South Walnut Creek between Ponds B-4 and B-5, and at site RC2 in Rock Creek below Lindsey Pond. A stable and healthy creek chub population was found at the upper two sites in Woman Creek (WO1 and WO2). A single specimen of longnose dace was also collected at site WO1. Otherwise, only one or two specimens of

fathead minnows were collected at the downstream sites in Walnut Creek (WC4 and WC5) and the lowest site in Rock Creek (RC3). These fish had likely washed into these locations from upstream areas during periods of increased discharges. While the intermittent nature of these streams obviously precludes the establishment of viable fish populations, macroinvertebrate populations were not as affected due to their ability to recolonize newly inundated habitats and their comparatively shorter life cycles.

The macroinvertebrate community was rich and diverse, and comprised mainly of hardy and tolerant species. The dominant organisms were similar in each drainage, with dipterans most abundant in Walnut and Rock Creeks, and oligochaetes most abundant in Woman Creek. The dipterans were mainly midge larvae (Chironomidae), while tubificid worms were the dominant oligochaetes. Ephemeroptera (mayflies) were relatively abundant throughout the drainages, and included moderate to tolerant taxa. Trichoptera (caddisflies) were generally present but in low numbers except at the effluent-dominated site in Walnut Creek (WC3). Interestingly, a relatively large plecopteran (stoneflies) population was found at one site in Rock Creek (RC3). Stoneflies were also collected in Woman Creek, but in considerably fewer numbers. HBI and ICI results further indicate the macroinvertebrate community was largely comprised of tolerant organisms. Comparisons with earlier studies of Rocky Flats streams and with the more recent studies of lower Walnut Creek and upper Big Dry Creek showed that community structure and abundance were somewhat similar to that found in Walnut, Woman, and Rock Creeks during the 2001-2002 study period.

1.0 INTRODUCTION

An aquatic monitoring program was initiated in the summer 2001 at the Rocky Flats Environmental Technology Site (Rocky Flats) in Golden, Colorado, and was conducted for the Department of Energy (DOE) Rocky Flats Field Office. The purpose of this program is to establish a data base to characterize the existing aquatic communities and habitat conditions in the stream environments of Walnut, Woman, and Rock Creeks in the Buffer Zone surrounding the Industrial Area at the Site. Baseline surveys were conducted to document the abundance and distribution of fish and benthic macroinvertebrate populations and physical habitat parameters at selected sampling locations. Monitoring results for the 2001-2002 period are presented in this report. These results and additional data collected in subsequent years will establish a data base that can be used to monitor the potential impacts of ongoing closure activities through 2006 to drainages on the Site and in downstream areas, as well as provide a baseline for comparison with post-closure years. After closure, the Site will be turned over to the U.S. Fish and Wildlife Service and will be called the Rocky Flats National Wildlife Refuge.

Planned site closure activities such as cessation of wastewater treatment plant operations by September 2004, removal of ponds in the Walnut and Woman Creek drainages, removal of buildings and impervious surfaces, and re-grading of remediated areas will undoubtedly affect the existing hydrologic regimes and water quality conditions, which may potentially influence aquatic environments and the aquatic communities inhabiting these areas. Upon closure of the wastewater treatment plant, periodic discharges from terminal ponds (Ponds A-4 and B-5) will be reduced resulting in significantly diminished flows in Walnut Creek, which will undoubtedly influence the aquatic environment.

Monitoring results will be compared with any relevant previous studies at the Site. Results will also be compared with the ongoing monitoring program on Big Dry Creek conducted since 1997 for the Cities of Broomfield, Northglenn, and Westminster, Colorado. DOE has provided significant funding for the Big Dry Creek project since 2000, which has allowed for the improvement and continuation of the program. Comparisons of Rocky Flats monitoring results with the ongoing studies on Big Dry Creek and Lower Walnut Creek will determine if any impacts have occurred in downstream areas as a result of closure activities.

The project study area includes the headwater reaches of Walnut, Woman, and Rock Creeks in the Buffer Zone. Both Walnut and Woman Creeks flow in an easterly direction extending to the eastern Site boundary at Indiana Street, while Rock Creek flows towards the northeast and leaves the Site at the northern boundary at State Highway 128. The project study area and locations of the 13 study sites are depicted in Figure 1. Five sites are located on Walnut Creek, with four sites on both Woman and Rock Creeks. Study site locations and existing flow characteristics are presented in Table 1. Sampling occasions and the types of samples collected at each site are presented in Table 2 for the 2001-2002 monitoring period.

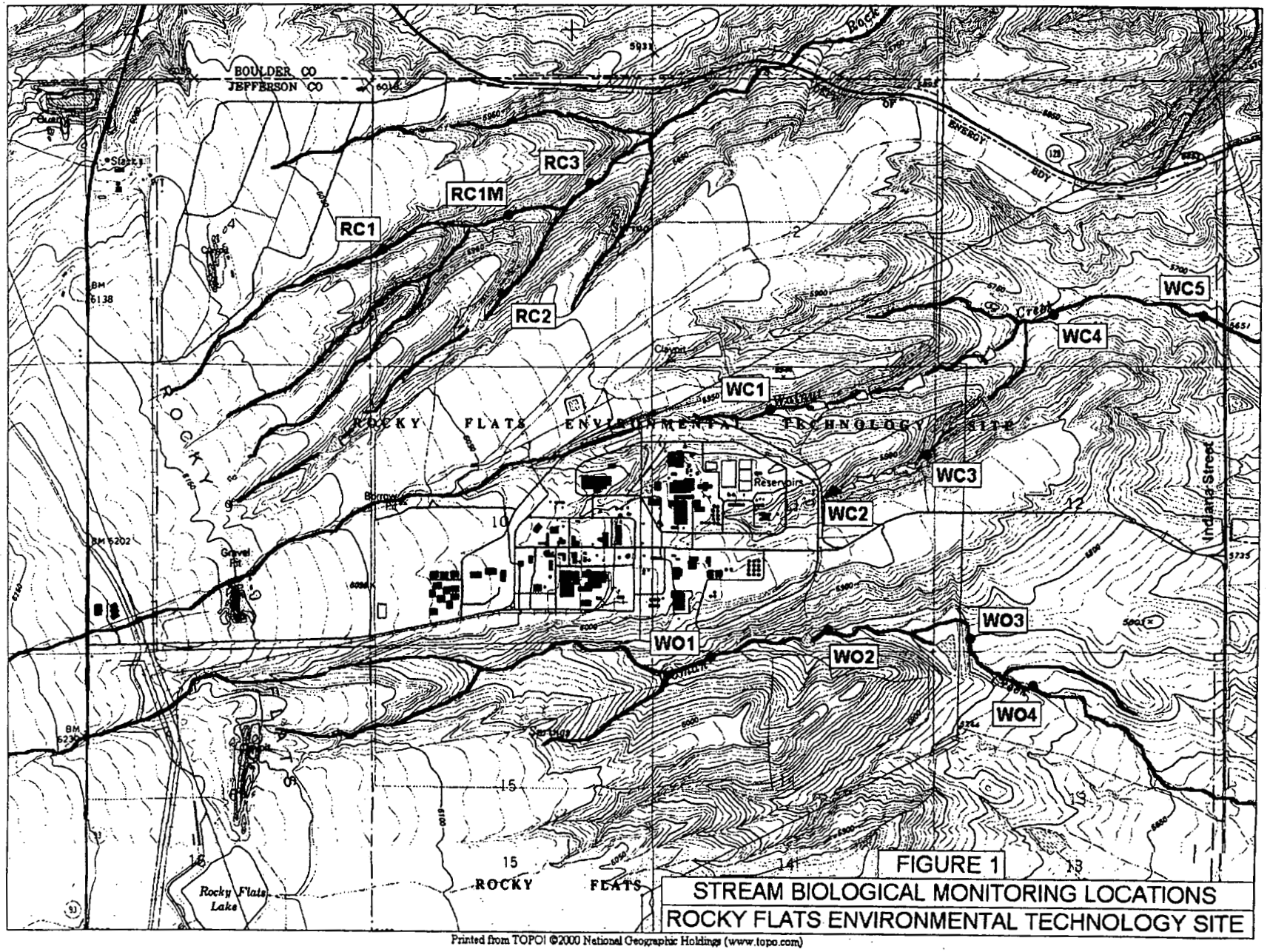


FIGURE 1
STREAM BIOLOGICAL MONITORING LOCATIONS
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

TABLE 1

BIOLOGICAL MONITORING SITES IN THE WALNUT, WOMAN, AND ROCK CREEK DRAINAGES AT ROCKY FLATS, 2001 AND 2002

Study Site	Location	Existing Flow Characteristics 1/
WALNUT CREEK		
WC1	North Walnut Creek below SW093, above A-1 Bypass	*P*
WC2	South Walnut Creek near GS10, above B-1 Bypass	*P*
WC3	South Walnut Creek downstream from Pond B-4, upstream from Pond B-5	*ED*
WC4	Mainstem Walnut Creek downstream from the confluence of North and South Walnut Creeks, downstream from terminal ponds and No Name Gulch	*DD*
WC5	Maintsem Walnut Creek upstream from GS03 and Indiana Street Pond	*DD*
WOMAN CREEK		
WO1	Woman Creek downstream from the confluence with Antelope Springs Creek, upstream from Pond C-1	*P*
WO2	Woman Creek downstream from Pond C-1	*P*
WO3	Pond C-2 Bypass, near toe of dam	*I*
WO4	Woman Creek downstream from Pond C-2, downstream from Mower Ditch	*I*
ROCK CREEK		
RC1	North Fork of Middle Fork Rock Creek	*P*
RC1M 2/	North Fork of Middle Fork Rock Creek upstream from confluence with Mainstem Rock Creek	*P*
RC2	Maintsem Rock Creek downstream from Lindsey Pond	*I*
RC3	Maintsem Rock Creek upstream from the confluence with the North and South Forks of Rock Creek	*I*

1/ Perennial, intermittent, effluent-dominated, and discharge-dependent flow characteristics are denoted by *P*, *I*, *ED*, and *DD*, respectively.

2/ Site RC1M was added to monitoring program in spring 2002.

TABLE 2

SAMPLING OCCASIONS AND TYPES OF SAMPLES COLLECTED AT WALNUT, WOMAN, AND ROCK CREEK MONITORING SITES AT ROCKY FLATS, 2001 AND 2002 1/

	2001		2002		
Study Site	summer	fall	spring	summer	fall
WALNUT CREEK					
WC1	*M, F*	*M, H*	*M*	*M*	*M, H*
WC2	*M, F*	*M, H*	*M*	*M*	*M, H*
WC3	*M, F*	*M, H*	*M*	*M*	*M, H*
WC4	*M, F*	*M, F, H*	*M*	dry	*M, H*
WC5	*M, F*	*M, F, H*	*M*	dry	*M, H*
WOMAN CREEK					
WO1	*M, F*	*M, H*	*M*	*M*	*M, H*
WO2	*M, F*	*M, H*	*M*	*M*	*M, H*
WO3	dry	*M, H* 2/	*M*	dry	*M, H*
WO4 3/	dry	not sampled	dry	dry	dry
ROCK CREEK					
RC1	*M*	*M, H*	*M*	*M*	*M, H*
RC1M 4/			*M*	*M*	*M, H*
RC2	*M, F*	*M, H*	*M*	*M*	*M, H*
RC3	*M, F*	*M, F, H*	*M*	dry	*M, H*

1/ Macroinvertebrate, fish, and habitat sampling are denoted by *F, M, HD*, and *H*, respectively.
2/ Qualitative habitat observations only at site WO3.
3/ Site WO4 was dry on most sampling occasions. Only remnant pools were observed in fall 2001, and sampling was not warranted.
4/ Site RC1M was added to monitoring program in spring 2002.

2.0 METHODS

2.1 PHYSICAL HABITAT

Physical habitat characteristics were measured in the fall. Physical data were collected in the immediate areas where fish and benthic macroinvertebrates were sampled. The assessment of habitat characteristics was performed to document annual changes in physical habitat considering site closure activities and to provide supplemental data for distinguishing between habitat and water quality effects on fish and macroinvertebrate communities inhabiting the various study sites.

Physical parameters were evaluated according to the most recent methods outlined for the Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al. 1999). This analysis allows for determining habitat differences between sites and documenting yearly changes at individual stream sites. The RBP analysis incorporates ten habitat parameters including available cover, pool substrate characterization, pool variability, sediment deposition, channel flow status, channel alteration, sinuosity, bank stability (erosion), bank vegetation protection, and riparian vegetation zone width. These habitat variables were measured in the field, and each parameter was rated as *optimal*, *suboptimal*, *marginal*, or *poor* based the data collected and scoring ranges designated for the RBP habitat assessment (Barbour et al. 1999). A total habitat assessment score was then calculated for each site by adding the ten habitat parameter scores. Habitat assessment scores may potentially range between 0 and 200, with higher scores generally indicating better habitat quality.

The presence and abundance of most fish and benthic macroinvertebrate species inhabiting a given stream reach are in part influenced by substrate composition and the relative amounts of macro-habitat (riffle, run, pool) available. Consequently, substrate composition and macro-habitat were also measured at study sites to supplement the RBP habitat analysis. Substrate particle size distribution was quantitatively measured at each site using the Wolman pebble count technique (Wolman 1954). Substrate particles were randomly selected and measured using a gravelometer template while traversing back and forth across transects until at total of 100 measurements were collected. Pebble count data were analyzed to determine the particle size distribution at each site for comparison with biological sampling results. Photographs of study sites were taken to document habitat conditions, and general habitat descriptions and observed changes were also recorded on all sampling occasions.

2.2 FISH POPULATIONS

Fish populations were sampled in the summer and/or fall, at study locations where flows were adequate for sampling. Backpack electroshocking equipment with one negative and one positive mobile electrode was used at each station. Fish were collected in one thorough pass through each representative stream reach. All fish captured were identified, counted, measured, and released to the stream unharmed. For each species, lengths and weights were measured for all individuals collected. When a large number of a single species was collected, specimens were counted and weighed collectively after a representative sample of individual fish was measured. Individuals were visually examined and the incidence of disease was recorded.

Sampling areas were representative of the stream reach and were of sufficient length to include all macro-habitats (riffle, run, pool) present. Natural physical barriers (very shallow depths over the riffle) prevented fish from moving into or out of the study reach. Study sites boundaries were permanently marked with rebar. The length of study areas ranged from approximately 44 to 169 meters (145 to 555 feet). Stream widths were measured at 9-meter (30 feet) intervals throughout each study section. Average stream widths ranged from approximately 0.6 to 1.7 meters (2.0 to 5.7 feet). Average stream width and total station length were used to calculate the area sampled. General site characteristics encountered at the time of sampling were recorded.

A list of fish species collected including the number collected, mean lengths and weights, and the number of age classes represented were determined for all study sites. More extensive fish population analyses (i.e. Index of Biotic Integrity) were inappropriate because of the lack of species diversity and low abundance. Such analyses may be performed a later date, if applicable, based on future sampling results.

2.3 MACROINVERTEBRATES

Macroinvertebrate sampling was performed in the spring, summer, and fall. Sampling was performed according to methods outlined by Klemm et al. (1990) and the Colorado Water Quality Forum (1995). Benthic macroinvertebrates were collected from representative aquatic habitats (riffle, run, pool, and bank) found at each site using a kick net with a mesh size of 425 microns (*um*). Kick net samples were collected from either a one-half or one-square meter area from representative habitats and were combined into one composite sample for analysis. The material collected in all samples was carefully placed into labeled sample containers and preserved with 10% formalin in the field. Samples were transported to the

laboratory for analysis. The feasibility of using artificial substrates (Hester-Dendy) sampling as an additional sampling method was evaluated based on observed water depth and flow conditions at each site.

Identification of macroinvertebrates and laboratory techniques were performed according to the methods outlined in Klemm et al. (1990). In the laboratory, samples were thoroughly rinsed of excess preservative and debris in a 500 *um* sieve before being placed in a white tray for processing. All macroinvertebrates were removed from the debris with forceps and placed in labeled vials filled with 80% ethanol. Macroinvertebrates were identified to the lowest taxonomic level possible with the aid of both binocular dissecting and compound microscopes using the appropriate taxonomic literature presented in Section 6.0. A macroinvertebrate reference collection was prepared, which contains representative specimens of each taxon in vials of 80% ethanol or on permanent slide mounts with Euparal or PVA (polyvinyl alcohol). Any new taxa encountered in future collections will be added to this project's reference collection.

Following identification and enumeration, a species list including the number of organisms collected, total density, total number of taxa, relative abundance, and diversity were calculated for each sample. Other community parameters were also calculated according to methods outlined for the Rapid Bioassessment Protocol III (RBP) analysis although reference site comparisons were deemed inappropriate (Barbour et al. 1999, Plafkin et al. 1989). The RBP metrics calculated included taxa richness, the modified Hilsenhoff Biotic Index (HBI), ratio of scrapers to filtering collector feeding groups, ratio of EPT to Chironomidae abundances, percent dominant taxon, the EPT Index, and the ratio of the shredder feeding group to the total number of individuals collected. Tolerance values used in the HBI incorporate values presented by Barbour et al. (1999), MDEQ (1996), Bode (1988), and Wetzel et al. (2000) which are applicable to Colorado streams. The HBI measures macroinvertebrate community responses to organic pollution. HBI values may range from 0 to 10, with higher values (generally >6) indicating higher degrees of organic pollution. The functional feeding group designations used were as provided by Barbour et al. (1999) and Merritt and Cummins (1996).

The Invertebrate Community Index (ICI) was also included in the evaluation of macroinvertebrate data to provide an additional objective measure of biological condition at study sites. ICI values were calculated according to methods outlined by DeShon (1995), which provide the detailed methodology used by the Ohio EPA for assessing the biological condition of streams in Ohio and the surrounding region. The ICI analysis involves scoring ten different metrics with the sum of these metrics providing the final index score. The metrics used include: 1) total number of taxa, 2) number of mayfly taxa, 3) number of caddisfly taxa, 4) number of dipteran taxa, 5) percent mayflies, 6) percent caddisflies, 7) percent of tribe

Tanytarsini midges, 8) percent other dipteran and non-insects, 9) percent tolerant organisms, and 10) number of qualitative ET (Ephemeroptera and Trichoptera) taxa. Each of these metrics is given a score of 6, 4, 2, or 0 depending on the value derived from macroinvertebrate data for each station. For tolerant species designations, any species with an HBI rating of 8 or higher was considered tolerant. Individual metric scores were determined by comparing derived values with species area plots for the reference data versus drainage area. A score of 6 for a given metric indicates the metric value is within the range exhibited by very good or exceptional aquatic communities, a score of 4 indicates that the value is characteristic of more typical or good communities, a score of 2 indicates the value is moderately deviating from the expected range of good to exceptional values, and a score of 0 indicates the value is strongly deviating from expected good or exceptional values. Final ICI scores were calculated for each site, and may range from 0 to 60. Corresponding benthic community condition ratings developed for the ICI are: *exceptional* (46-60), *good* (36-45), *fair* (13-35), and *poor* (0-12) (DeShon 1995).

3.0 RESULTS

3.1 PHYSICAL HABITAT

Physical habitat characteristics for sites in the Walnut, Woman, and Rock Creek drainages at Rocky Flats and the results of the Rapid Bioassessment Protocol (RBP) habitat assessment are provided herein. RBP habitat assessment results are summarized in Tables 3, 4, and 5 for the fall 2001 and 2002 sampling occasions for sites on Walnut, Woman, and Rock Creeks, respectively. Habitat assessments were conducted at all sites on Walnut and Rock Creeks, and at only two of the four sites on Woman Creek. Quantitative habitat assessments could not be performed at sites WO3 and WO4 on Woman Creek due to the lack of water; however, reconnaissance level surveys were conducted at these sites in conjunction with habitat measurement and macroinvertebrate sampling events. Total habitat assessment scores and individual parameter scores and their corresponding condition categories are presented in the tables for the ten habitat parameters incorporated in the assessment. This assessment was performed during the months of October and November in 2001 and 2002; consequently, total scores reflect the flow conditions typical of the fall season. Additional results are also provided for summer conditions based on observations made concurrent with the biological sampling conducted in the summer of 2001 and 2002. Photographs of study sites and habitat features are provided in Appendix A, and substrate particle size distribution plots are provided in Appendix B.

3.1.1 Walnut Creek

Site W1 is located in the upper reaches of North Walnut Creek, below SW093 and above the A-1 Bypass (Figure 1 and Table 1). This site is also downstream from the discharge of the Solar Pond Plume ground water treatment system. The water was usually clear, and discharges were typically low on most sampling occasions although a significant increase in discharge and turbidity was observed at this site during a storm event in August 2001. Alternating riffle-run and pool habitats with small to medium cobble, course gravel, and sand substrates were predominant. Riffle-run areas were shallow, while pools were moderate to large in size and relatively deep (0.5-3 feet). The channel is heavily shaded by trees and shrubs, which somewhat limit periphytic and filamentous algae growth. A diverse mix of grasses and other non-woody vegetation is also present. About half of the reach has steep vertical banks with exposed soils, which increase the potential for erosion particularly during storm events.

TABLE 3

SUMMARY OF RAPID BIOASSESSMENT PROTOCOL (RBP) HABITAT ASSESSMENT SCORES FOR WALNUT CREEK SITES, FALL 2001 AND 2002

WALNUT CREEK

Habitat Parameter	WC1 Score	WC1 Condition Category	WC2 Score	WC2 Condition Category	WC3 Score	WC3 Condition Category	WC4 2/ Score	WC4 2/ Condition Category	WC5 2/ Score	WC5 2/ Condition Category
Bottom Substrate/ Available Cover	14	Suboptimal	17	Optimal	13	Suboptimal	11	Suboptimal	12	Suboptimal
Pool Substrate Characterization	16	Optimal	17	Optimal	11	Suboptimal	14	Suboptimal	13	Suboptimal
Pool Variability	16	Optimal	11	Suboptimal	11	Suboptimal	11	Suboptimal	16	Optimal
Sediment Deposition	18	Optimal	16	Optimal	18	Optimal	18	Optimal	17	Optimal
Channel Flow Status 1/	17	Optimal	17	Optimal	18	Optimal	18	Optimal	18	Optimal
summer condition	11	Suboptimal	7	Marginal	18	Optimal	n/a		n/a	
Channel Alteration	19	Optimal	15	Suboptimal	19	Optimal	19	Optimal	19	Optimal
Channel Sinuosity	7	Marginal	6	Marginal	6	Marginal	8	Marginal	8	Marginal
Bank Stability 3/										
2001	4	L-Marginal	3	L-Marginal	1	L-Poor	4	L-Marginal	1	L-Poor
	4	R-Marginal	3	R-Marginal	1	R-Poor	4	R-Marginal	2	R-Poor
2002	no change		no change		0	L-Poor	2	L-Poor	3	L-Marginal
					0	R-Poor	3	R-Marginal	4	R-Marginal
Bank Vegetative Protection	9	L-Optimal	7	L-Suboptimal	8	L-Suboptimal	8	L-Suboptimal	8	L-Suboptimal
	9	R-Optimal	7	R-Suboptimal	8	R-Suboptimal	9	R-Optimal	9	R-Optimal
Riparian Vegetation Zone Width	10	L-Optimal	3	L-Marginal	9	L-Optimal	10	L-Optimal	10	L-Optimal
	10	R-Optimal	8	R-Suboptimal	9	R-Optimal	10	R-Optimal	10	R-Optimal
Total Scores 2001	153		130		132		144		143	
2002	no change		no change		130		141		147	
Summer Condtions	147		120		130		n/a		n/a	

1/ Channel flow status observed during summer conditions.
2/ Scores at sites WC4 and WC5 when discharges from terminal ponds occurring; otherwise channel dry (total score = 0).
3/ Bank stability was the only habitat parameter that changed between the fall 2001 and 2002 assessments.

TABLE 4

SUMMARY OF RAPID BIOASSESSMENT PROTOCOL (RBP) HABITAT ASSESSMENT SCORES FOR WOMAN CREEK SITES, FALL 2001 AND 2002 1/

WOMAN CREEK

Habitat Parameter	WO1 Score	WO1 Condition Category	WO2 Score	WO2 Condition Category	WO3 Score	WO3 Condition Category	WO4 Score	WO4 Condition Category
Bottom Substrate/ Available Cover	14	Suboptimal	15	Suboptimal				
Pool Substrate Characterization	16	Optimal	16	Optimal				
Pool Variability	10	Marginal	16	Optimal	qualitative measurements only 3/		lack of water precluded quantitative assessment 4/	
Sediment Deposition	18	Optimal	18	Optimal				
Channel Flow Status 2/	18	Optimal	18	Optimal				
summer conditions	8	Marginal	8	Marginal				
Channel Alteration	19	Optimal	19	Optimal				
Channel Sinuosity	6	Marginal	6	Marginal				
Bank Stability	10	L-Optimal	8	L-Suboptimal				
	10	R-Optimal	6	R-Suboptimal				
Bank Vegetative Protection	9	L-Optimal	9	L-Optimal				
	9	R-Optimal	9	R-Optimal				
Riparian Vegetation Zone Width	9	L-Optimal	9	L-Optimal				
	9	R-Optimal	9	R-Optimal				
Total Score	157		158					
Summer Conditions	147		148					

1/ No change in habitat parameters observed between the fall 2001 and 2002 assessments.
2/ Channel flow status observed during summer conditions.
3/ Water only occasionally present; thus, quantitative habitat assessment not warranted at site WO3.
4/ Quantitative habitat assessment may be performed at site WO4 in future based on water availability.

TABLE 5

SUMMARY OF RAPID BIOASSESSMENT PROTOCOL (RBP) HABITAT ASSESSMENT SCORES FOR ROCK CREEK SITES, FALL 2001 AND 2002 1/

ROCK CREEK

Habitat Parameter	RC1 Score	RC1 Condition Category	RC1M 2/ Score	RC1M 2/ Condition Category	RC2 Score	RC2 Condition Category	RC3 Score	RC3 Condition Category
Bottom Substrate/ Available Cover	3	Poor	13	Suboptimal	8	Marginal	14	Suboptimal
Pool Substrate Characterization	11	Suboptimal	17	Optimal	13	Suboptimal	18	Optimal
Pool Variability	1	Poor	16	Optimal	14	Suboptimal	16	Optimal
Sediment Deposition	19	Optimal	18	Optimal	18	Optimal	18	Optimal
Channel Flow Status 3/	18	Optimal	18	Optimal	18	Optimal	18	Optimal
summer conditions	16	Optimal	7	Marginal	1	Poor	0	Poor
Channel Alteration	19	Optimal	19	Optimal	19	Optimal	19	Optimal
Channel Sinuosity	7	Marginal	6	Marginal	6	Marginal	8	Marginal
Bank Stability	10	L-Optimal	8	L-Suboptimal	10	L-Optimal	10	L-Optimal
	10	R-Optimal	8	R-Suboptimal	10	R-Optimal	10	R-Optimal
Bank Vegetative Protection	8	L-Suboptimal	10	L-Optimal	8	L-Suboptimal	10	L-Optimal
	8	R-Suboptimal	10	R-Optimal	8	R-Suboptimal	10	R-Optimal
Riparian Vegetation Zone Width	10	L-Optimal	10	L-Optimal	10	L-Optimal	10	L-Optimal
	9	R-Optimal	10	R-Optimal	10	R-Optimal	10	R-Optimal
Total Score	133		163		152		171	
Summer Conditions	131		152		135		153	

1/ No change in habitat parameters observed between the fall 2001 and 2002 assessments.
2/ Site RC1M added to monitoring program in spring 2002; habitat assessment performed at this site in fall 2002.
3/ Channel flow status observed during summer conditions.

Site WC2 is located on South Walnut Creek at site GS10 and upstream from the Pond B-1 Bypass. This site receives discharges from the Mound Plume ground water treatment system, which is situated upstream (west) of the North Access Road. This reach includes large deep pools (2.5-4.0 feet) at both the upstream and downstream ends, which are connected by a narrow riffle-run that flows though a dense stand of willows. Water was usually clear with moderate to heavy growths of filamentous algae in the pools. Substrates consisted mainly of silt, sand, gravel, and small to medium cobble. Banks were covered with tall grasses. This site is exposed as there are no trees in the immediate area.

Site WC3 is on South Walnut Creek between Ponds B-4 and B-5. Wastewater Treatment Plant effluent is discharged to Pond B-3, which is upstream from Pond B-4. Thus flows at this site are relatively stable and about 90% effluent-dominated (Fiehweg 2003). South Walnut Creek also receives discharge from the East Trenches Plume ground water treatment system that flows into Pond B-4. Water was typically green in color due to an abundance of planktonic algae from the upstream ponds and the fact that water is effluent-dominated. The channel is deeply incised (10-15 feet). Stream banks were very unstable and actively eroding. Banks are steep and vertical with exposed soils throughout most of the study reach. Alternating riffle, run, and pool sequences are common. Substrates were predominately clay with gravel and small to medium cobble mainly in riffle areas (Appendix B). Bank vegetative cover was diverse and included a good mix of grasses, forbs, shrubs, and trees. Numerous trees provided some shade over the stream channel.

Sites WC4 and WC5 are located on the mainstem of Walnut Creek. Site WC4 is located downstream from confluence of North and South Walnut Creeks, and downstream from No Name Gulch and Pond B-5. Site WC5 is near the eastern boundary of the Rocky Flats Site, upstream from GS03 and the Indiana Street Pond. Currently, discharge at these sites is largely dependent on periodic discharges from the terminal ponds (Ponds A-4 and B-5). These discharges are usually 2 to 4 c.f.s., and typically occur at 4 to 6-week intervals depending on the season and precipitation events (Stover 2002). Otherwise, the channel is dry during most of the year, except during storm events. When discharges occurred, riffle, run, and pool habitats were evident. Substrates at both sites were generally similar to those found at sites WC1 and WC2, consisting mainly of small to medium cobble, gravel, sand, and silt (Appendix B). Isolated pools remained at these sites for short durations (days to a few weeks) following the end of discharge events. However, such temporary hydrologic conditions are inadequate for the establishment of viable fish and macroinvertebrate populations, and currently, most of the biota collected at these sites are transients that have either washed in from upstream areas or have flown in from adjacent water bodies. Although there are some trees at these sites, the channel is mostly exposed. Grasses are predominant with

a variety of forbs and shrubs also present. Even though banks were grass covered, substantial erosion was evident at both sites, which is exacerbated by the periodic discharges.

RBP habitat assessment scores ranged from 130 to 153 for Walnut Creek sites (of a possible maximum score 200) for the fall 2001 and 2002 sampling events (Table 3). The highest habitat score was calculated for site WC1 (153). Scores were lower but similar at sites WC2 (130) and WC3 (130 and 132), while scores were 144 and 141 for site WC4, and 143 and 147 for site WC5 in 2001 and 2002, respectively. Note that the scores at sites WC4 and WC5 are for periods when the terminal pond discharges are occurring in an otherwise dry channel, which would result in a total score of 0 for most of the year. Scores for summer conditions were 147, 120, and 130 for sites WC1, WC2, and WC3, respectively, based on flow conditions observed at these sites during the summer season. Although summer scores were considerably less than fall scores for sites WC1 and WC2, habitat scores for site WC3 were the same for the fall and summer periods primarily because flows are consistent and seasonally stable.

There were no measurable habitat changes at sites WC1 and WC2 between the fall 2001 and 2002 assessments, thus habitat scores were the same. In downstream areas, bank stability (erosion) was the only habitat parameter that changed at sites WC3, WC4, and WC5 between the fall 2001 and 2002 assessments. More bank erosion, as evidenced by the dry and crumbling soils along the vertical stream banks, was measured at sites WC3 and WC4, which resulted in a decrease in the bank stability score and the total habitat score at these sites. While changes in bank stability were also measurable at site WC5 along the left and right stream banks, erosion was less evident at this site in the fall 2002; consequently, the total score at site WC5 improved slightly in 2002 (Table 3). Some eroded areas that were observed during the previous fall were now re-vegetated by grasses and had apparently stabilized during the 2002 growing season. Discharges from the terminal ponds were less frequent during the 2002 drought year with a 10% decrease in discharge quantity from 2001 levels (RFETS 2003). With the resulting lower flows at this site, the erosion of exposed soils was less and banks have had a chance to heal themselves. Although these same flow regimes occurred at site WC4 in 2002, similar improvements in bank stability were not observed because the banks are comparatively higher and more vertical than at site WC5.

3.1.2 Woman Creek

Flows in upper Woman Creek drainage (sites WO1 and WO2) are generally low and permanent with discharge sustained by ground water seeps. In addition, leakage from Rocky Flats Reservoir also provides some recharge to the watershed (Fiehweg 2003). Flow fluctuations are also influenced by

seasonal transpiration rates of riparian vegetation, which is greatest in the summer. Consequently, the lowest flows were observed at study sites during summer months, while flows increased notably in the fall in both 2001 and 2002 likely in response to decreased transpiration rates. While flows are permanent at sites WO1 and WO2, flows diminish considerably farther downstream in the vicinity of Pond C-2 to the extent that discharge was only evident at site WO3 in the fall 2001, and in the spring and fall 2002. Farther downstream, the channel was usually dry except on one occasion when only standing water was present in remnant pools at site WO4 near the Mower Ditch diversion.

Site WO1 on Woman Creek is located downstream from the confluence with Antelope Springs Creek, and upstream from Pond C-1. The stream flows through a grove of young cottonwood trees and an area of dense mature willows. Short riffle and pool sequences were common in the lower portion of the reach while the upper section is mostly riffle-run habitat. This reach is shallow with two larger pools (0.8 feet deep) and numerous small pocket pools created by cobbles and boulders. Substrates were predominantly cobble (mostly medium to large) interspersed with gravel and sand. Some small boulders were also present. Banks were stable and grass covered. Rushes and sedges were found both within and along the stream channel. Some filamentous algae growth was also present, but mostly in the summer.

Site WO2 is located approximately 250 feet downstream from Pond C1. The stream also flows through a grove of cottonwood trees at this site, which provides considerable shade in the upper portion of the reach, and then through a dense stand of mature willows farther downstream. Alternating riffle and pool habitats were predominant. Although the pools were fewer, they were comparatively larger and deeper (1.0-1.4 feet) than those found at site WO1, and the riffles were wider and longer. Cobble was also the dominant substrate with some gravel and sand. Deposits of fine organic sediment and iron precipitates were observed in the pools. Because the channel is somewhat shaded, periphyton and filamentous algae growth was only slight to moderate. Stream banks were generally stable and covered with grasses; however, some erosion was evident in the upper portion of the study reach.

Site WO3 is located in the Pond C-2 Bypass, near the toe of the dam. This reach includes a short section of riffle-run habitat with coarse sand and small gravel substrates. Several pools, some of which are fairly large and moderately deep (1.0-1.5 feet), were also present and often covered by mats of filamentous green algae when water was present. Pool substrates consisted mostly of sand and silt with some organic matter. Vegetation was generally scarce in this area and consisted mainly of grasses with a few willows and young cottonwood trees.

Site WO4 is downstream from Pond C-2 and confluence with Mower Ditch. The lack of water at this site during the 2001-2002 study period precluded conducting any level of habitat assessment. An assessment will be performed in the future when sufficient flows are available to warrant such an effort.

RBP habitat assessment scores for the two upper sites on Woman Creek were similar between sites and seasons (Table 4). Total scores were 157 and 158 for sites WO1 and WO2, respectively, and 147 and 148 for summer flow conditions. There were no changes in any of the habitat parameters measured between the fall 2001 and 2002 assessments. Although total scores were similar at the two sites, there were some habitat parameter differences (pool variability and bank stability). There is permanent water at sites WO1 and WO2 throughout the year, but flows are generally low and seasonally intermittent in the drainage, and habitat quality decreases primarily due to diminishing flows during the summer months.

3.1.3 Rock Creek

Sites RC1 is located on the North Fork of the Middle Fork of Rock Creek. Aquatic habitat is largely sustained by numerous permanent ground water seeps. This site is situated immediately downstream from a cattail marsh where flows first emerge to form a discernible channel. Flows were always very low but seasonally stable during all sampling events. The stream flows into two small shallow pools, through a dense stand of cattails, and into an open grassy meadow area. The substrate was mainly medium to large cobble over a firm mud/clay bottom that was often covered by iron precipitates and heavy growths of filamentous and periphytic algae. Duckweed was also abundant. Stream banks were well vegetated with a good diversity of grasses, sedges, and other wetland plants. A diverse mix of woody shrubs (such as willow, wild plum, common choke cherry, indigobush, and others) and a few trees are common throughout the Middle Fork drainage. Because of the wetland character and stable perennial flows, aquatic habitat at site RC1 is the most diverse of all sites in of Rock Creek as well as in the other drainages.

Site RC1M is also on the North Fork of the Middle Fork, upstream from the confluence with the mainstem of Rock Creek (Figure 1). This site was added to the monitoring program in the spring 2002. While flow is also permanent at this site and sustained by ground water seeps, discharge was seasonally more variable than observed at site RC1. This study reach includes numerous riffle and pool sequences. Four of the five pools were relatively large and deep (0.9-2.0 feet) for a stream of this size. Gravel and small to medium cobble were the predominant substrates with some sand and fine organic sediment in the pools. The cobble was covered by periphytic algae and iron precipitates. Duckweed and watercress were

also abundant in both pool and riffle habitats. Stream banks were mostly grass covered although some erosion was noted in areas where the stream is confined by the hillside. This site also had a good diversity of woody shrubs as found at site RC1 with several trees also present.

Site RC2 is on the mainstem of Rock Creek, downstream from Lindsey Pond. This site is distinctly different from sites RC1 and RC1M in that the stream flows through an open meadow area and dense stands of cattails (Appendix A). Although some shrubs were present, there was only one willow tree at the top of the reach. The study reach included five pools that were moderate in size but rather deep (1.1-2.6 feet) with overhanging grasses with a soft muddy bottom laden with organic detritus. A narrow shallow riffle-run channel connected the pools. Gravel and small to medium cobble overlaid the firm mud/clay bottom in riffle-run segments. Prolific growths of filamentous algae, duckweed, and watercress were usually present. Flow was observed at this site on all sampling occasions, except during the drought summer 2002 when the channel was dry and only standing water remained in two of the pools at this site.

Site RC3 is located on the mainstem of Rock Creek upstream from the confluence with the North and South Forks. Discharge was present on most sampling events, except in the drought summer of 2002. In summer months, the stream disappears in places and then resurfaces, illustrating the intermittent nature of Rock Creek in the downstream reaches. The stream meanders though a small grove of cottonwoods and mature willows with a good diversity of alternating riffle, run, and pool habitats. Pools were numerous and moderate to large in size and were relatively deep (0.6-1.7 feet) with overhanging grasses. Substrates were mostly cobble interspersed with gravel and sand with deposits of organic sediment in the pools. Filamentous and periphytic algae and some watercress were also found in the pools, although growth was usually not as heavy as observed at the other Rock Creek sites. Stream banks were stable and well vegetated with a diverse mix of grasses, forbs, shrubs, and trees.

RBP habitat assessment scores varied widely for sites on Rock Creek (Table 5). Site RC1 had the lowest habitat score mainly because of the obvious lack of cover and pool habitat (for aquatic life), but had the least seasonal flow variation of all the Rock Creek sites because of ground water seeps in the upper drainage. Flow conditions are somewhat similar throughout the year at site RC1 and to a lesser extent at site RC1M due to ground water seeps in upper Rock Creek drainage. However, these seeps diminish in a downstream direction and the creek becomes more intermittent at sites RC2 and RC3.

Total habitat scores were similar for site RC1 for fall and summer conditions (133 and 131). Habitat scores were 163, 152, and 171 for sites RC1M, RC2, and RC3, respectively. Scores were comparatively

lower for these sites during summer flow conditions (152, 135, and 153) with the greatest score differences observed at sites RC2 and RC3 due to the lack of water. Only standing water was present in two pools at site RC2, and site RC3 was completely dry in the drought summer 2002. The lack of water during summer months is the most limiting factor affecting habitat quality and adversely affects the establishment of fish and macroinvertebrate populations in Rock Creek.

3.1.4 Summary of Habitat Assessment Results

Habitat scores were generally highest in the Rock Creek drainage with scores comparable to those for sites WO1 and WO2 in Woman Creek, and site WC1 in upper Walnut Creek (Tables 3, 4, and 5). Overall, the lowest scores were recorded for sites WC2, WC3, WC4, and WC5 in Walnut Creek and for RC1 in the upper reaches of Rock Creek. The lower scores in Walnut Creek reflect the generally poor condition of stream banks, which is further aggravated at sites WC4 and WC5 by the periodic discharges from the terminal ponds. The low score at RC1 was mainly due to the lack of cover and pool habitat.

The lower scores recorded for the four downstream sites in Walnut Creek and the upper site in Rock Creek ranged between 130 and 147 during the 2001-2002 study period. Habitat assessment scores were also similar (124 to 136) to those reported for the Big Dry Creek monitoring program conducted in 2000 and 2001, which included sites in lower Walnut Creek and upper Big Dry Creek near the confluence of Walnut Creek (Aquatics Associates, Inc. 2002).

An earlier habitat assessment study was conducted at numerous sites in Walnut and Woman Creeks at Rocky Flats and in upper Big Dry Creek between November 1994 and January 1995. Although the older EPA methodology was used (Plafkin et al. 1989) in this effort, the same general trends in scores were evident for the Walnut Creek drainage with the highest score reported for a site on North Walnut Creek (near WC1), while scores were comparatively lower for several sites on South Walnut Creek (near WC3) and the mainstem downstream to the Indiana Street Pond (near WC4 and WC5) (Wright Water Engineers, Inc. 1995). Similarly, high scores were reported for sites in the Woman Creek drainage, which were in proximity to sites WO1, WO2, and WO3. This study did not include an assessment of habitat in the Rock Creek drainage.

3.2 FISH POPULATIONS

Fish populations were sampled at nine of the study sites in Walnut, Woman, and Rock Creeks in August 2001 (Table 2). Fish were present at seven of the nine sites as described below. Follow-up surveys were conducted at sites WC4 and WC5 in October 2001, to further verify fish abundance during more suitable sampling conditions since only few specimens were collected initially. Insufficient flows precluded sampling at sites RC1, WO3, and WO4. No sampling was performed during the 2002 drought year as fish populations were adequately documented with the 2001 effort. However, future sampling is planned for 2003 to determine the stability of fish communities in streams at the Rocky Flats Site considering the 2002 drought. Subsequent efforts will include sampling at site RC1M, which was added to the monitoring program in spring 2002 and has not yet been sampled.

Fish were collected at only seven of the nine study sites during the 2001 monitoring period as listed in Table 6. Fish population data presented for these sites include the number of fish collected, mean lengths and weights, and the number of age classes for representative species. Naturally self-sustaining fish populations were found at only four sites, namely WC3, WO1, WO2, and RC2. A viable population of fathead minnows was found at site WC3 on Walnut Creek and at site RC2 on Rock Creek (below Lindsey Pond). A total of 298 fathead minnows (*Pimephales promelas*) were collected at site WC3, while 185 fatheads were collected at site RC2. Both juvenile and adult fish were collected at these sites. In Woman Creek, a stable and healthy creek chub (*Semotilus atromaculatus*) population was found at both sites WO1 and WO2, which included 3 and 4 consecutive age classes, respectively. One longnose dace (*Rhinichthys cataractae*) was also collected at site WO1.

In August, no fish were collected at sites WC1, WC2, or WC4, and only one fathead minnow each was collected at sites WC5 and RC3. Sites WC4 and WC5 were re-sampled in October to better document the population and the potential effects of periodic discharges in the lower reaches of Walnut Creek. No additional fish were collected at site WC5 in October. No fathead minnows were collected from pools that remained at site WC4 after the October discharge event. The fact that only one or two fathead minnow specimens were collected at sites WC4, WC5, and RC3 suggests that these fish have likely washed into to these locations from upstream areas (where viable populations exist) during periods of increased discharges.

TABLE 6

FISH POPULATION SAMPLING RESULTS FOR SITES IN
WALNUT, WOMAN, AND ROCK CREEKS AT ROCKY FLATS, 2001

Site	Fish Species	Number Collected	Mean Length (mm	Mean Weight (g)	Number of Age Classes
WALNUT CREEK 1/					
WC3	Fathead Minnow	298	27 (24-73)	0.2 (0.1-6)	2
WC4	Fathead Minnow	2	58 (46, 69)	2.5 (1.5, 3.5)	1
WC5	Fathead Minnow	1	52	2	1
WOMAN CREEK 2/					
WO1	Creek Chub	11	81 (35-120)	7 (0.5-17)	3
	Longnose Dace	1	72	3	1
WO2	Creek Chub	46	98 (26-219)	18 (0.5-94)	4
ROCK CREEK 2/					
RC2	Fathead Minnow	185	63 (40-81)	3 (0.8-5.5)	2
RC3	Fathead Minnow	1	50	1.5	1

1/ No fish were collected at sites WC1 or WC2.
2/ Sampling not performed at sites WO3, WO4, and RC1 due to insufficient flows.

The longnose dace, creek chub, and fathead minnow are all native species in the South Platte River Basin and are common in cool water transition zone streams with low siltation (Nessler et al. 1997). Longnose dace is the only intolerant species (Barbour et al. 1999). The fathead minnow is a silt tolerant species and is fairly ubiquitous throughout the South Platte River and tributaries. The three species that were collected at Rocky Flats in 2001 were also common at sites in lower Walnut Creek and upper Big Dry Creek near the confluence of Walnut Creek, which were sampled as part of the Big Dry Creek monitoring program (Aquatics Associates, Inc. 2002).

In an earlier fish survey conducted at Rocky Flats during the summer of 1991, which did not include Rock Creek, fathead minnows were also the only species collected from various sites in the Walnut Creek drainage (U.S. Department of Energy 1992). In Woman Creek, creek chubs were also collected during the 1991 study, along with six other species including central stoneroller (*Campostoma anomalum*), fathead minnow, golden shiner (*Notemigonus crysoleucas*), white sucker (*Catostomus commersoni*), green sunfish (*Lepomis cyanellus*), and largemouth bass (*Micropterus salmoides*). However, no longnose dace were collected. The fact that this study included more sites (nine vs. two) than the 2001 study may in part explain why more species were collected. Nonetheless, all of these species were recently found at the various sites sampled for the Big Dry Creek monitoring program (Aquatics Associates, Inc. 2002). Future monitoring will further document species abundance and distribution as well as fish population stability in drainages at the Rocky Flats Site.

3.3 MACROINVERTEBRATES

The macroinvertebrate community was sampled in the streams environments of Walnut, Woman, and Rock Creeks at the Rocky Flats Site (Figure 1 and Table 1). Macroinvertebrate samples were collected on five occasions on a seasonal basis from the summer 2001 to fall 2002. The percent relative abundance for important and/or predominant species collected in the three drainages are provided in Tables 7, 8, and 9 for Walnut, Woman and Rock Creeks, respectively. A complete species list is presented in Appendix C that includes the occurrence of individual taxa collected at each site during the 2001-2002 sampling period. Trends in number of taxa and density for all sites and seasons are provided in Figure 2, while percent relative abundance is shown in Figure 3. Species diversity and Hilsenhoff Biotic Index (HBI) values are depicted in Figure 4. Invertebrate Community Index (ICI) scores are shown in Figure 5. Summaries of total density, percent relative abundance of taxonomic groups, and important community parameters, as well as the detailed data (list of species, relative abundance, total density, number of taxa, and other community parameters for each site and sampling event) are provided in Appendices D and E for 2001 and 2002, respectively.

Overall, the macroinvertebrate community was very diverse and abundant with most species being tolerant of the extreme environmental conditions that are characteristic of transitional foothills-plains streams environments. The perennial, intermittent, or flow interrupted nature of the stream environments encountered provides a diversity of aquatic habitats such as both shallow lotic and lentic conditions, remnant pools, spring seeps, and wetland areas within the stream channel, all of which support a correspondingly diverse macroinvertebrate fauna. Flow conditions at most sites are perennial or seasonally intermittent, but are presently effluent-dominated at site WC3 and discharge-dependent at sites WC4 and WC5 in Walnut Creek. Seasonal taxa richness was lowest in the summer of 2002 with 95 taxa, which was likely related to the record drought conditions, and was highest in summer 2001 when 140 taxa were collected (Appendix C).

Total densities varied widely among sites and seasons, which is typical of macroinvertebrate communities of flow limited streams, especially considering the potential for significant flow fluctuations during localized storm events in these drainages. Total densities ranged from 36,038 organisms per square meter (organisms/m^2) at site RC3 in the fall 2002, to only 189 organisms/m^2 at site WO3 also in the fall 2002 (Figure 2, Appendices D and E). The predominant macroinvertebrate group collected in all three drainages during the sampling period was Diptera (true flies). Dipteran mean percent relative abundance

TABLE 7

MEAN PERCENT RELATIVE ABUNDANCE FOR PREDOMINANT AND IMPORTANT MACROINVERTEBRATE SPECIES COLLECTED IN WALNUT CREEK FOR SEASONS AND SITES SAMPLED, 2001 AND 2002

	Seasonal Means					Site Means				
	2001		2002							
Taxa	Summer	Fall	Spring	Summer	Fall	WC1	WC2	WC3	WC4	WC5
OLIGOCHAETA (aquatic worms)										
Enchytraeidae	0.3	5.0	0.1	0.1	0.5	0.3	<0.1	<0.1	5.5	3.6
Tubificidae	12.4	3.8	0.8	1.1	8.3	6.7	1.2	0.3	5.3	23.8
AMPHIPODA (scuds)										
Hyalella azteca	23.2	8.3	6.4	33.5	9.5	21.3	26.2	17.4	nc *	0.3
EPHEMEROPTERA (mayflies)										
Baetis tricaudatus	5.0	8.5	1.4	9.7	4.3	0.5	nc	23.8	<0.1	nc
Callibaetis sp.	1.8	4.1	0.2	1.7	0.9	0.4	5.8	0.3	1.6	0.8
ODONATA (dragonflies and damselflies)										
Argia sp.	2.1	2.4	3.5	1.0	1.0	6.7	0.9	0.6	nc	nc
HEMIPTERA (true water bugs)										
Trichocorixa borealis	0.2	0.3	nc	nc	38.1	nc	nc	nc	33.3	31.0
TRICHOPTERA (caddisflies)										
Cheumatopsyche sp.	3.2	3.5	0.3	4.2	1.4	nc	nc	10.8	<0.1	nc
Limnephilus sp.	nc	3.0	0.4	nc	0.7	1.9	0.7	0.1	2.0	0.1
DIPTERA (true flies)										
Chironomidae (midges)										
Chironomus sp.	11.0	0.7	9.8	0.3	0.1	0.4	6.1	0.2	18.2	0.5
Cricotopus sp.	5.3	0.3	5.2	1.5	0.3	0.1	2.0	6.7	1.2	0.6
Dicrotendipes sp.	3.1	0.2	0.6	2.5	0.2	nc	5.0	0.2	0.2	0.1
Micropsectra sp.	2.1	1.1	16.6	16.7	0.7	10.8	10.2	1.0	2.7	0.5
Nilotanypus sp.	0.5	nc	8.6	0.3	nc	5.8	<0.1	nc	nc	nc
Paratendipes sp.	0.3	3.7	1.6	4.4	1.3	5.9	2.8	0.1	nc	0.1
Radotanypus sp.	0.2	1.9	0.5	3.8	0.8	4.9	0.4	nc	nc	0.3
Thienemannimyia group	0.4	1.9	9.6	0.2	0.3	7.4	0.8	0.3	nc	<0.1
Simulidae (black flies)										
Simulium vitattum complex	5.5	1.1	20.9	0.6	7.1	3.3	0.6	21.2	2.3	0.4
GASTROPODA (snails)										
Physa sp.	3.9	22.2	0.4	3.6	11.1	3.6	19.8	0.4	11.1	15.5

* nc indicates species not collected.

TABLE 8

MEAN PERCENT RELATIVE ABUNDANCE FOR PREDOMINANT AND IMPORTANT MACROINVERTEBRATE SPECIES COLLECTED IN WOMAN CREEK FOR SEASONS AND SITES SAMPLED, 2001 AND 2002

	Seasonal Means					Site Means		
	2001	2002						
Taxa	Summer	Fall	Spring	Summer	Fall	WO1	WO2	WO3
OLIGOCHAETA (aquatic worms)								
Aulodrilus pigueti	2.8	nc *	nc	17.7	14.6	nc	16.9	nc
Enchytraeidae	nc	0.5	0.1	nc	13.3	0.2	nc	13.6
Nais communis	4.1	12.3	4.5	2.1	8.2	8.6	8.7	0.4
Tubificidae	18.5	23.1	2.3	41.8	23.3	24.5	6.0	38.1
AMPHIPODA (scuds)								
Hyalella azteca	28.4	6.5	0.6	17.9	0.2	3.6	19.3	nc
EPHEMEROPTERA (mayflies)								
Caenis bajaensis	6.1	13.3	11.5	nc	0.1	14.2	3.1	nc
DIPTERA (true flies)								
Chironomidae (midges)								
Chironomus sp.	0.1	1.0	1.2	3.5	1.9	nc	3.2	1.2
Micropsectra sp.	1.0	3.1	7.4	nc	5.4	4.8	0.7	7.4
Odontomesa sp.	nc	nc	20.9	nc	nc	9.0	3.4	0.1
Rheocricotopus sp.	nc	1.8	nc	nc	9.5	0.6	6.1	nc
Tanytarsus sp.	0.0	0.7	6.0	1.9	nc	0.4	4.4	nc
Simulidae (black flies)								
Simulium vitattum complex	0.1	3.2	12.5	nc	0.7	0.9	1.9	11.6
GASTROPODA (snails)								
Physa sp.	6.8	1.5	0.1	1.0	4.5	4.7	2.1	nc

* nc indicates species not collected.

TABLE 9

MEAN PERCENT RELATIVE ABUNDANCE FOR PREDOMINANT AND IMPORTANT MACROINVERTEBRATE SPECIES COLLECTED IN ROCK CREEK FOR SEASONS AND SITES SAMPLED, 2001 AND 2002

	Seasonal Means					Site Means			
	2001	2002							
Taxa	Summer	Fall	Spring	Summer	Fall	RC1	RC1M	RC2	RC3
TURBELLARIA (flatworms)									
Dugesia sp.	0.8	3.4	0.6	8.1	4.3	3.3	10.6	1.6	0.1
OLIGOCHAETA (aquatic worms)									
Nais communis	0.8	2.3	1.1	0.2	6.7	0.6	3.4	4.1	1.8
Tubificidae	13.8	6.9	15.1	31.3	13.5	16.9	13.0	25.9	4.3
AMPHIPODA (scuds)									
Hyalella azteca	16.4	6.3	3.6	32.4	6.1	18.0	20.0	10.6	0.2
EPHEMEROPTERA (mayflies)									
Caenis bajaensis	2.8	5.2	10.5	0.3	6.5	2.2	14.5	7.7	<0.1
Callibaetis sp.	0.2	1.3	0.1	nc	4.4	nc	0.1	2.5	2.4
Fallceon quilleri	2.8	8.3	2.9	1.6	2.9	4.9	2.4	5.7	0.1
PLECOPTERA (stoneflies)									
Capnura wanica	nc *	9.7	nc	nc	1.3	nc	nc	nc	8.6
DIPTERA (true flies)									
Ceratopogonidae (biting midges)	0.3	0.6	5.8	0.1	0.5	3.6	1.7	0.9	0.1
Chironomidae (midges)									
Chironomus sp.	0.2	0.3	nc	0.1	5.5	nc	0.2	2.4	2.9
Cricotopus sp.	nc	0.5	4.7	nc	1.8	0.1	3.7	1.0	2.8
Micropsectra sp.	2.3	9.0	0.5	nc	8.7	1.0	0.5	2.1	13.4
Nilotanypus sp.	1.0	nc	3.7	2.5	nc	2.5	3.7	0.2	<0.1
Tanytarsus sp.	nc	0.7	9.3	0.4	1.7	5.3	4.1	0.9	1.0
Simulidae (black flies)									
Simulium vitattum complex	5.8	12.4	1.4	nc	3.7	4.5	1.6	7.3	2.7
GASTROPODA (snails)									
Physa sp.	14.7	13.0	0.5	1.3	1.9	11.2	1.2	0.6	8.6
BIVALVIA (fingernail clams)									
Pisidium sp.	0.3	0.7	0.7	6.8	3.4	5.7	3.3	0.3	nc

* nc indicates species not collected.

FIGURE 2

DENSITY AND TOTAL NUMBER OF TAXA COLLECTED AT SITES IN WALNUT, WOMAN, AND ROCK CREEKS AT ROCKY FLATS, 2001 AND 2002

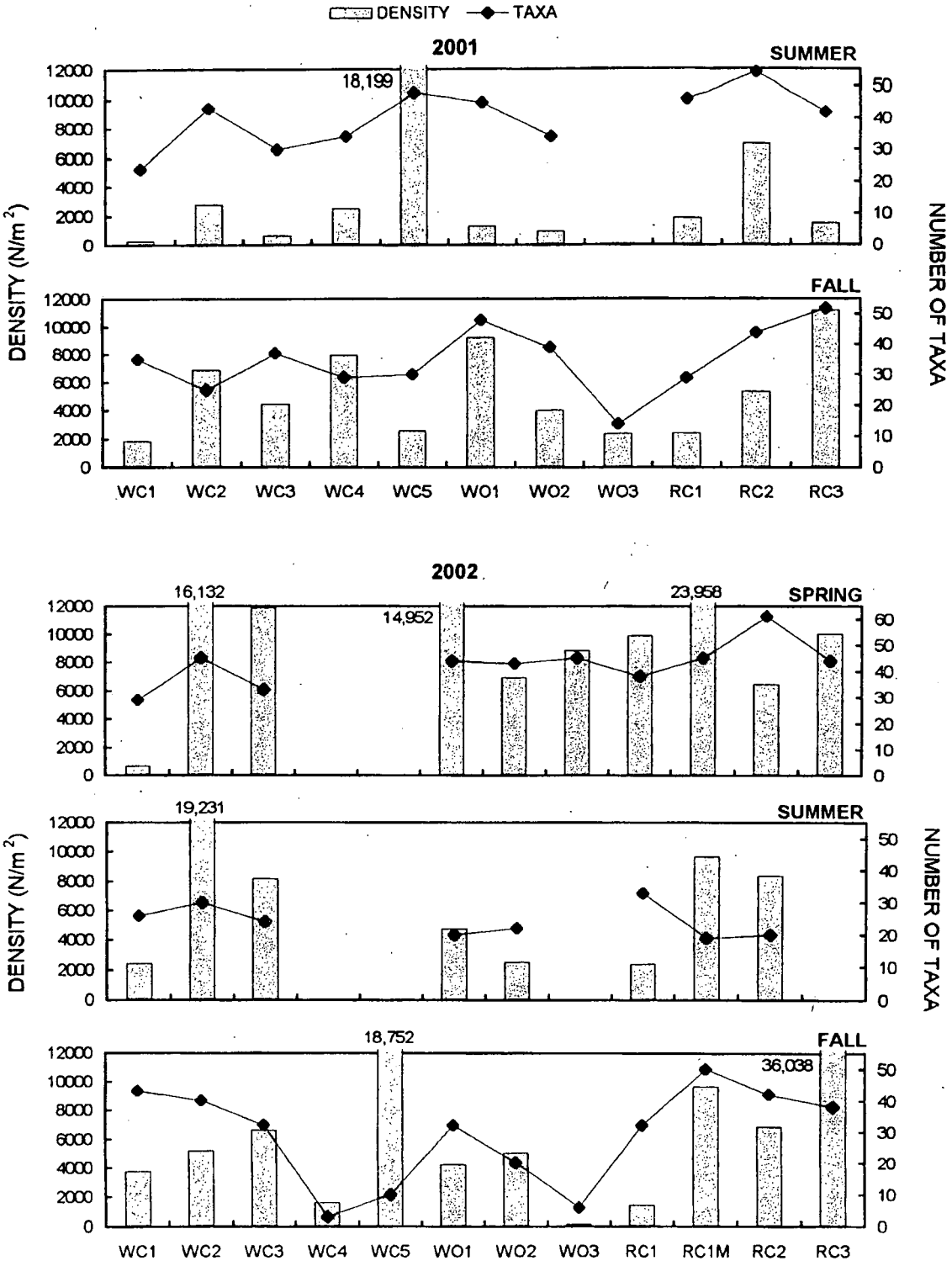


FIGURE 3

PERCENT RELATIVE ABUNDANCE OF MACROINVERTEBRATE TAXONOMIC GROUPS COLLECTED AT SITES IN WALNUT, WOMAN, AND ROCK CREEKS AT ROCKY FLATS, 2001 AND 2002

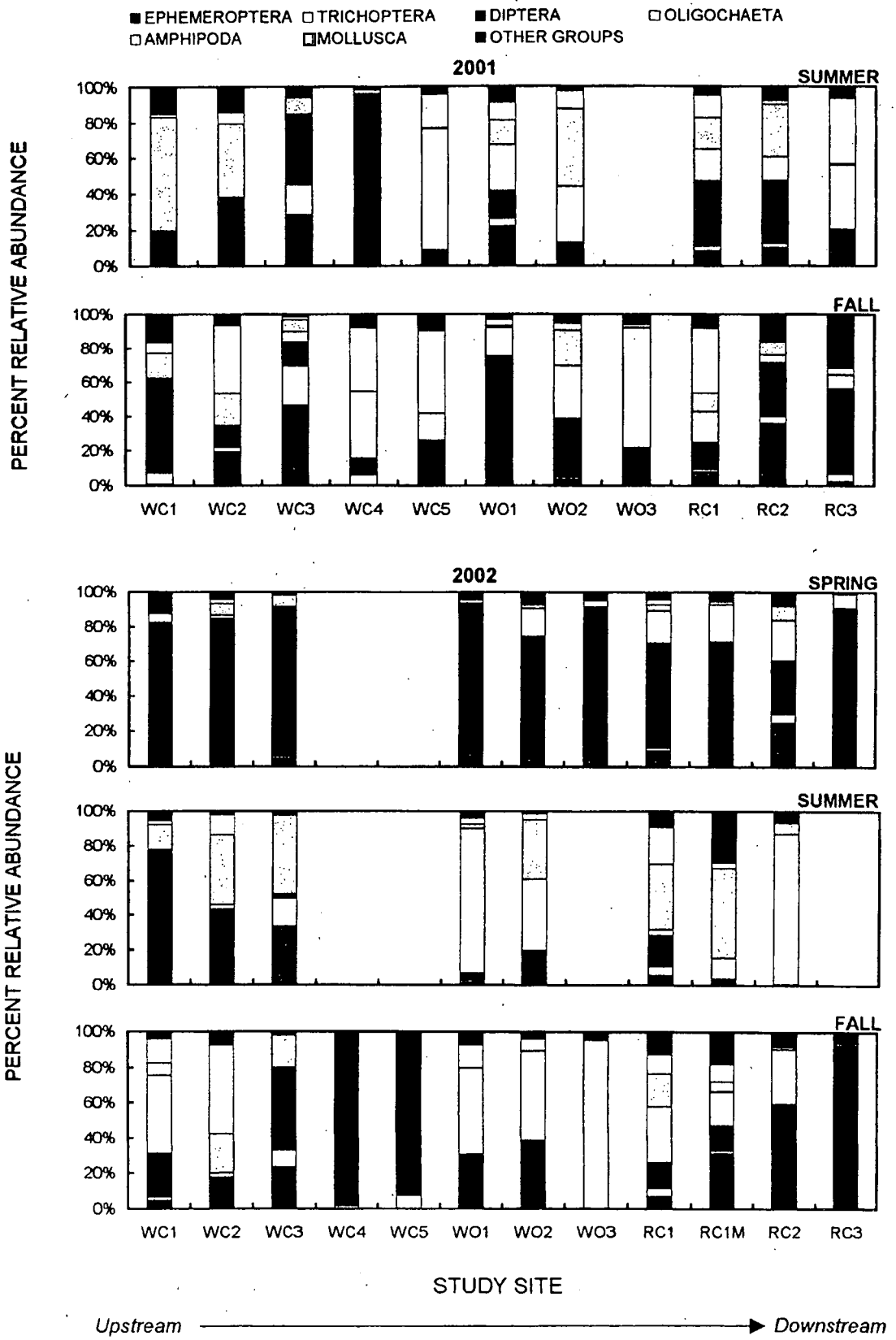


FIGURE 4

HILSENHOFF BIOTIC INDEX (HBI) AND SPECIES DIVERSITY VALUES FOR STUDY SITES IN WALNUT, WOMAN, AND ROCK CREEKS, 2001 AND 2002

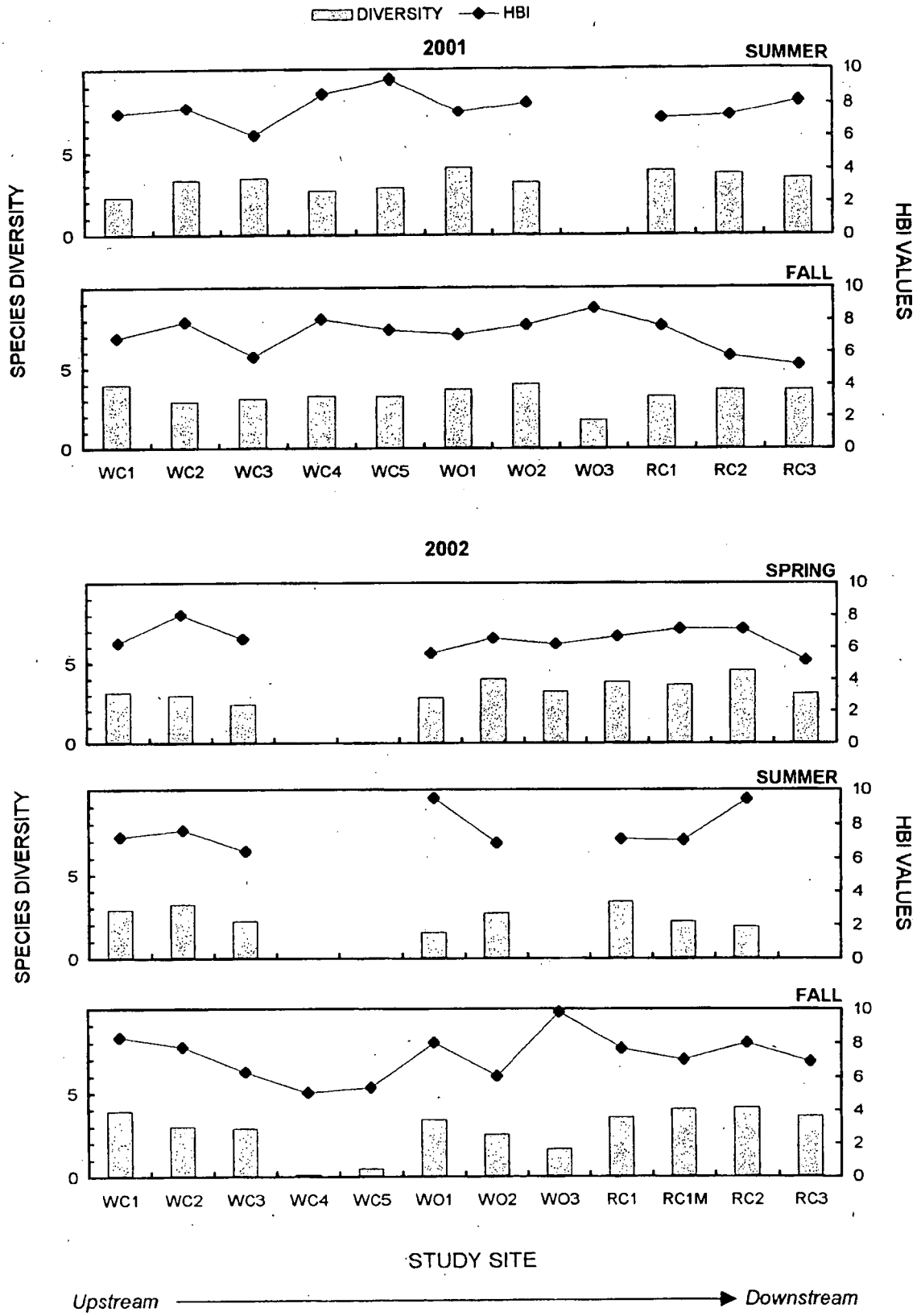
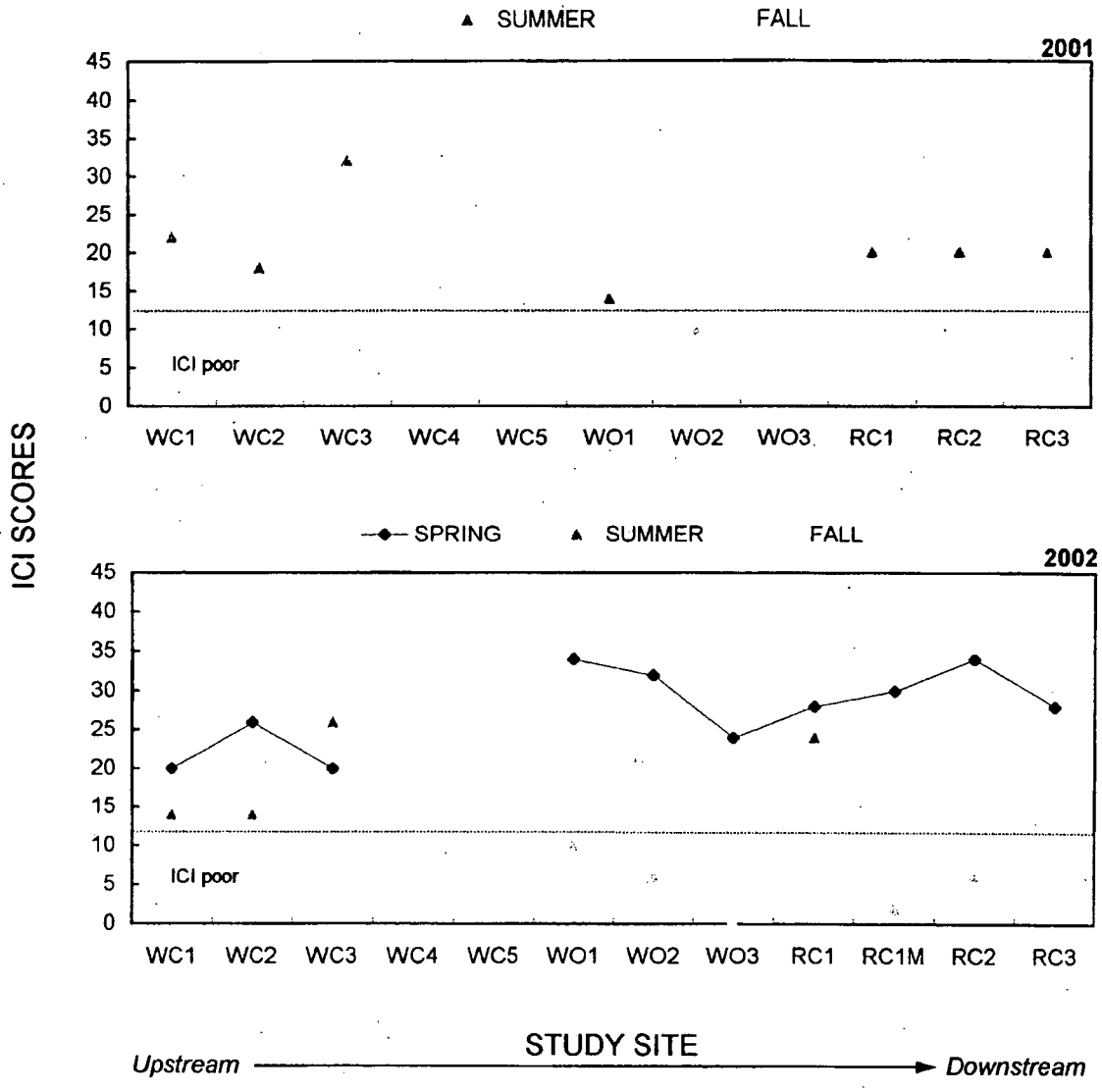


FIGURE 5

INVERTEBRATE COMMUNITY INDEX (ICI) SCORES FOR STUDY SITES IN WALNUT, WOMAN, AND ROCK CREEKS, 2001 AND 2002



for all sampling events and sites was 34.3% with the highest mean abundance recorded in spring 2002 at 69.5% and the lowest in the summer 2002 at 19.3%. Dipteran mean percent relative abundance in Woman and Rock Creeks was nearly equal at 29.7 and 33.2%, respectively; while in Walnut Creek the mean was 39.9%. Of the dipterans collected the vast majority were of the family Chironomidae (midges). Chironomid taxa comprised between 62.0 and 74.2% of the dipteran taxa collected for the five sampling events. Oligochaeta (aquatic worms), Amphipoda (scuds), Mollusca (snails and fingernail clams), and Ephemeroptera (mayflies) were also generally abundant at most sites and seasons. Notably scarce in these drainages were significant numbers and taxa of Odonata (dragonflies and damselflies), Hemiptera (true water bugs), and Trichoptera (caddisflies). Specific characteristics of the macroinvertebrate community found in each drainage are discussed below.

3.3.1 Walnut Creek

The macroinvertebrate community in Walnut Creek was similar to the other streams at Rocky Flats and was dominated by dipterans, especially chironomids (Figure 3, Appendices D and E). During the sampling period, Diptera comprised an average of 39.9% of the macroinvertebrate community and ranged from 17.2% in fall 2002 to 83.2% in spring 2002. The most abundant dipterans were the chironomids *Chironomus* sp., *Cricotopus* sp., and *Micropsectra* sp. (Table 7). Both *Chironomus* sp. and *Micropsectra* sp. are collector-gatherers, whereas *Cricotopus* sp. is primarily a shredder. The filter feeding black flies, *Simulium vittatum* complex were also relatively abundant, especially at site WC3, which receives effluent-dominated flows throughout the year. These are all common and ubiquitous species in Colorado Front Range streams. These species have tolerance values ranging between 6 and 10, indicating their moderate to high tolerance of organic pollution and general hardiness (Barbour et al. 1999).

The second most abundant macroinvertebrates in Walnut Creek were the non-insect group Amphipoda (scuds or freshwater shrimp), all of which were *Hyalella azteca*. This species is common in slow moving or standing water environments, is widespread, and has a broad tolerance (value of 8) to a number of environmental variables (Smith 2001). Overall, their mean percent abundance was 16.2% of the macroinvertebrate community in Walnut Creek with the highest abundances observed during the summer seasons when their reproductive activity is greatest (Table 7). Over the sampling period, *Hyalella azteca* was most abundant at sites WC1, WC2, and WC3 with mean abundances of 17.4 to 26.2%, although they were absent at site WC4 and sparse at site WC5.

Mayflies were relatively abundant in Walnut Creek with an overall mean abundance of 8.5% during the study period. While mayflies were always present and most abundant at site WC3 (23.5 to 46.6%RA on four of five occasions), they were occasionally either absent or present at <1%RA at the other sites (Figure 3). *Baetis tricaudatus* and *Callibaetis* sp. were the predominant mayflies in Walnut Creek (Table 7). *Baetis tricaudatus* was found almost exclusively at site WC3 (23.8%RA), whereas *Callibaetis* sp. was collected at all sites, but was most abundant at site WC2 (5.8%RA). *Baetis tricaudatus* is moderately tolerant of organic pollution (value of 5), whereas *Callibaetis* sp. is rather tolerant (value of 9). All mayflies collected were collector-gatherers indicating the availability of detritus as a food source for these organisms.

Oligochaetes were present at most all sites during the study period with an overall mean abundance of 8.1% and were found sporadically in high numbers at sites WC1 (44.0%RA in fall 2002), WC4 (39.3%RA in fall 2001), and WC5 (67.7, 15.5, and 7.4%RA in summer 2001, fall 2001, and fall 2002, respectively). Tubificid worms were the most abundant taxa except on one occasion when enchytraeids were more abundant (Table 7). Overall, tubificids were most abundant at site WC5 with a mean abundance of 23.8% and to a lesser extent at sites WC1 and WC4. Pools with soft fine sediment substrates are the preferred habitats of these organisms. Although the channel is often dry at sites WC4 and WC5 when periodic discharges from the terminal ponds are not occurring, these organisms can form cysts allowing them to survive desiccation or periodically moist conditions for short durations (Kaster and Bushnell 1981). These organisms may also wash downstream into these sites from the terminal ponds. Tubificids and enchytraeids are pollution tolerant (value of 10).

Odonata (dragonflies and damselflies) were most often collected at sites WC1 and WC2 in pool habitats where mean abundances were 7.6 and 4.7%RA, respectively. The overall mean abundance was 3.2% for all Walnut Creek sites. The damselfly, *Argia* sp. was the predominant species, which was most numerous at site WC1 with a mean abundance of 6.7% (Table 7). This species is moderately tolerant (value of 7).

Caddisflies were found almost exclusively at site WC3 where the filter-feeding *Cheumatopsyche* sp. was predominant and averaged 10.8%RA for the sampling period (Table 7). The consistent effluent-dominated flows at this site undoubtedly favor colonization by this species. *Limnephilus* sp. on the other hand was collected at all sites, but represented only 2.0%RA or less of the community. Limnephilids are shredders and are less dependent on flowing water than the *Cheumatopsyche* sp., thus they were more widespread within the drainage.

Sites WC4 and WC5 were the only sites in Walnut Creek (and the other two drainages) where Hemiptera (true water bugs) were collected in significant numbers. This group was dominated by the adult water boatman *Trichocorixa borealis,* which was very abundant in the fall 2002 with overwhelming abundances of 98.3 and 92.4% at sites WC4 and WC5, respectively (1,628 and 17,328 organisms/m^2). Although the channel was completely dry prior to the discharge event in October 2002, adults of this ubiquitous species rapidly colonized the remnant pools found at these sites shortly after cessation of pond discharges.

Gastropods comprised an average of 9.6% of the macroinvertebrate population in Walnut Creek during the sampling period. Gastropods were most abundant at sites WC2, WC4, and WC5 in fall 2001, and at WC2 in fall 2002, accounting for 33.2 to 45.7%RA on these occasions. The common and tolerant species, *Physa* sp. was by far the dominant taxon (Table 7). The mean abundance of *Physa* sp. was highest in fall 2001 when it comprised 22.2% of the total community. *Physa* sp. was generally most abundant at site WC2 with a mean abundance of 19.8%.

Total densities in Walnut Creek were similar to most flow limited intermittent streams showing wide temporal and spatial variations (Figure 2). Densities ranged from to 264 to 19,231 organisms/m^2 at sites WC1 and WC2 in the summer of 2001 and 2002, respectively. At site WC3 where flows are effluent-dominated, seasonal densities ranged from 674 organisms/m^2 (summer 2001) to 11,886 organisms/m^2 (spring 2002). The overall mean density for all sites and sampling events was 7,097 organisms/m^2 (range 1,807-13,187 organisms/m^2). Species richness ranged from 24 to 48 taxa, except at sites WC4 and WC5 in 2002 when only 3 and 10 taxa were collected in the fall, and in the spring and summer when no samples were collected at these sites because the channel was dry. Considering all sites and seasons, the fewest number of taxa collected was 55 during the drought summer of 2002, whereas the most taxa (96) were collected in summer 2001.

Species diversity values for all sites were moderately high and ranged from 2.23 at site WC3 in summer 2002, to 3.98 at site WC1 in fall 2001, when the very low diversity values for sites WC4 and WC5 in the fall 2002 are ignored (0.13 and 0.48, respectively) (Figure 4). These low values resulted due to the overwhelming numbers of trichocorixids at these two sites. Overall, species diversity values were moderately high with a mean diversity of 2.69 for all sites, and 3.06 for sites WC1, WC2, WC3. These values indicate that the Walnut Creek macroinvertebrate community includes a moderately diverse assemblage of organisms although the majority of the taxa are moderate to highly tolerant of environmental stresses.

Furthermore, the elevated HBI values and the low ICI scores also indicate the community is dominated by moderate to highly tolerant organisms (Figures 4 and 5, respectively). HBI values ranged from 5.07 to 9.45 (HBI values approaching 10 indicate a higher degree of community tolerance). ICI scores also indicate a moderately stressed macroinvertebrate community; however, none of the scores for Walnut Creek were rated as *poor* (Figure 5). Of the 21 sampling events, 20 had scores ranging from 14 to 34, which were in the *fair* category (13 to 35), and on one occasion the score was in the *good* category (38 at site WC3 in fall 2001). Overall, the mean ICI score was 19.4 for the Walnut Creek drainage, and mean ICI scores ranged from 14.0 to 29.6 for individual sites. The highest mean score was at site WC3 where stream flows are stable and consistently higher than at the upper two sites. Of all the sites, flows are probably most suitable at site WC3, providing the most favorable conditions for aquatic life. In contrast, sites WC4 and WC5 had the lowest mean ICI scores at 16.0 and 14.0, respectively, likely due to the interrupted flow regime, which prevents the establishment of a stable community at these sites.

3.3.2 Woman Creek

In Woman Creek, the upper two sites generally had sufficient flows to collect macroinvertebrate samples, whereas farther downstream at site WO3, the channel was dry on two out of five sampling events (summer 2001 and 2002). Overall, the most abundant macroinvertebrate group collected was Oligochaeta, which represented 40.5% of the macroinvertebrate community over the five sampling events. This group was dominant on most occasions with a mean relative abundance of 28.4 to 65.1%, except in the spring 2002 when Diptera were most numerous (Figure 3, Appendices D and E). Tubificids were the predominant oligochaete; however, other taxa such as *Nais communis* and *Aulodrilus pigueti* were also relatively abundant as found in Walnut Creek (Table 8). The enchytraeids were only abundant at site WO3 in the fall 2002, although they were common in Walnut Creek. Seasonal abundance of tubificids typically ranged from 18.5 to 41.8% with the highest abundance occurring in drought summer 2002. Tubificids tended to be most numerous at site WO1, where their total densities were generally highest of the three sampling locations (Appendices D and E). *Nais communis* were common in all seasons and were most abundant at sites WO1 and WO2 with percent relative abundances of 8.6 and 8.7%, respectively. *Aulodrilus pigueti* on the other hand was only collected at site WO2 and was not collected in the fall 2001 or spring 2002 (Table 8).

In contrast to Walnut Creek, dipterans were the second most abundant group in Woman Creek with an overall average relative abundance of 29.7% compared to 39.9% in Walnut Creek. Seasonally, Diptera represented 11.8 to 69.9%RA during the sampling period. While dipterans were most abundant in spring

2002, they were least abundant in drought summer 2002. Chironomids were by far the predominant dipterans. Some of the abundant midges were also common to Walnut Creek such as, *Micropsectra* sp. and *Chironomus* sp. However, *Odontomesa* sp., *Rheocricotopus* sp. and *Tanytarsus* sp. were found to be more abundant in Woman Creek (Table 8) and are moderately tolerant of organic pollution (values between 4 and 6). The black flies, *Simulium vittatum* complex were also common but were less abundant than in Walnut Creek because of the scarcity of desirable flowing water habitat in Woman Creek.

Amphipods were always numerous in the summer and were the third most abundant group with an overall mean relative abundance of 11.2%. The ubiquitous *Hyalella azteca* was the most abundant taxon and was predominantly found at site WO2 (19.3%RA), which has the most permanent pool habitat of the three sampling sites.

Mayflies were fairly common at sites WO1 and WO2 with an overall average abundance of 8.6% for the study period. Mayflies were most numerous from the summer 2001 through the spring 2002 (22.2 to 39.1%RA at site WO1, and 0.4 to 14.1%RA at WO2). However, by the summer and fall 2002, mayflies became scarce at site WO1 and were not collected at site WO2, likely in response to drought conditions. Only one mayfly species was relatively abundant, *Caenis bajaensis*, which is moderately tolerant (value of 7). This species was most abundant at site WO1 and most numerous in the fall 2001 and spring 2002 collections (Table 8). *Caenis bajaensis* is a collector-gatherer that prefers quiet water and soft sediments as found in the pool habitats at sites WO1 and WO2.

Considerably fewer caddisflies and damselflies were collected in Woman Creek than in Walnut Creek. The filter-feeding taxon, *Cheumatopsyche* sp. prefers water flowing over gravely areas to build its detritus catching nets. This type of habitat is scarce in Woman Creek.

Gastropods comprised an average of 3.5% of the macroinvertebrate community and consisted mainly of the species *Physa* sp. This common tolerant species was found most often at site WO1 (4.7%) and during the summer 2001 and fall 2002 sampling seasons (Table 8).

Interestingly, Plecoptera were collected in Woman Creek, although they were not particularly abundant. Only one species, *Capnura wanica* was collected at sites WO1 and WO3, and their abundance was <1% and 2.1%RA, respectively.

Total densities were variable ranging from 189 organisms/m^2 at site WO3 in fall 2002 to 14,952 organisms/m^2 at site WO1 in spring 2002 (Figure 2, Appendices D and E). Total densities were highest at site WO1 and lowest at site WO3. Overall, the mean density for the study period was 4,874 organisms/m^2 in Woman Creek (compared to 7,097 organisms/m^2 in Walnut Creek). Taxa richness also varied with a maximum of 48 taxa at site WO1 in fall 2001, and only 6 taxa collected at site WO3 in fall 2002. Site WO3 has always been dry for the summer sampling event, although sufficient flows were present by November in both 2001 and 2002, which allowed for sampling. Consequently, the lack of permanent water at this site (and site WO4) limits colonization and establishment of a diverse benthic community, which was most evident during the 2002 drought. Considering all sites and seasons, the total number of taxa collected in the Woman Creek drainage ranged from 32 to 87, with the fewest number of taxa collected during the drought summer of 2002 (Appendix C).

Species diversity values were moderately high and similar to Walnut Creek with an overall mean diversity of 2.90. Diversity values ranged between 1.59 at WO1 in summer 2002, to 4.11 at site WO1 in summer 2001 (Figure 4). Overall, species diversity was higher at the two upper sites, and comparatively lower at site WO3 likely due to the fact that this site is frequently dry.

HBI values indicate that the majority of the taxa collected were moderate to highly tolerant of environmental stresses. HBI values were generally higher in Woman Creek than in Walnut Creek ranging from 5.63 at site WO1 (spring 2002) to 9.83 at site WO3 (fall 2002) (Figure 4). The high HBI value (near maximum of 10) at site WO3 resulted because the highly tolerant tubificid worms, which have a tolerance value of 10, comprised nearly 96% of the entire macroinvertebrate community in the fall 2002.

ICI scores indicate the Woman Creek macroinvertebrate community was stressed in 2001 and 2002, as 6 of the 13 sampling events had scores in the *poor* category (0-12) (Figure 5). Site WO3 had the lowest ICI scores with 2 in fall 2001 and 0 in fall 2002. Six of the scores were rated as *fair*, ranging from 14 to 34. Only one score was in the *good* category (40 at site WO1 in fall 2001). Mean ICI scores indicate the macroinvertebrate community in Woman Creek is the most stressed of the three drainages studied. The overall mean ICI score was 15.6 for the drainage. Mean ICI scores were 22.4, 15.6, and 8.7 at sites WO1, WO2, and WO3, respectively, indicating site WO3 was most stressed likely due to the lack of permanent water.

3.3.3 Rock Creek

Observed flows in Rock Creek were generally low during the 2001-2002 sampling period and were especially low during the drought summer of 2002. The entire channel was dry at site RC3, thus no sampling was performed, and only a few remnant pools were available for sampling at site RC2. Similar to Walnut Creek, Rock Creek was dominated by dipterans, which overall comprised 33.2% of the macroinvertebrate community for the sampling period. Seasonal mean abundance for dipterans typically ranged from 30.5 to 55.5%, but was only 7.2%RA in the summer 2002 (Figure 3, Appendices D and E). As in the other drainages, chironomids were by far the most abundant of the dipterans, as were the predominant species of *Chironomus* sp., *Cricotopus* sp., and *Micropsectra* sp. (Table 9). Other relatively abundant chironomids were *Nilotanypus* sp., a predator and *Tanytarsus* sp., a collector-gatherer. Both are moderately tolerant (values of 6). The black fly larvae, *Simulium vittatum* complex were also common throughout the drainage. These black flies were most abundant at site RC2 and were most numerous in fall 2001 (Table 9). Although not very numerous in the other two drainages, biting midges of the family Ceratopogonidae were relatively abundant in Rock Creek, especially at site RC1.

Oligochaeta was the second most abundant group and overall comprised 21.0% of the macroinvertebrate community. They were generally most abundant at site RC2, especially in the summer 2002 when they accounted for 86.6% of the macroinvertebrate community (Figure 3, Appendix E). Tubificid worms were the most abundant taxon and overall represented 15.0%RA of the community for all sites and seasons. These worms were most abundant at site RC2 where their mean abundance was 25.9% for the study period (Table 9). However, they were not as well represented at site RC3 (4.3%RA) because of the overwhelming numbers of dipterans (20.3 to 85.8%RA). Although not as numerous as the tubificids, *Nais communis* was also common and most abundant at site RC2.

The amphipod *Hyalella azteca* was also a predominant species in Rock Creek, with an overall mean abundance of 13.0%. Again, they were most abundant in the summer collections. Mean abundances were 18.0, 20.0, and 10.6%RA at sites RC1, RC1M, and RC2, respectively. However, they were either scarce or absent at site RC3 where the overall mean abundance was only 0.2% (Table 9).

Mayflies were most abundant in Rock Creek compared to the other two drainages, and the overall mean abundance was 10.7%. *Caenis bajaensis, Callibaetis* sp., and *Fallceon quilleri* were the most common mayflies and were generally collected at all sites and seasons (Table 9). While *Caenis bajaensis* was numerically dominant at site RC1M (14.5%RA), *Callibaetis* sp. was nearly equal in abundance at sites

RC2 and RC3 (2.5 and 2.4%RA). *Fallceon quilleri* was relatively abundant at sites RC1 and RC2 (4.9 and 5.7%RA). The feeding habit of *Fallceon quilleri* is a collector-gatherer like the other mayfly species.

Of particular interest is the fact that stoneflies were very numerous in Rock Creek, but only at site RC3. Stonefly densities were 3,270 and 1,840 organisms/m^2 in fall of 2001 and 2002, and 10 organisms/m^2 in the spring 2002 (Appendices D and E). Stoneflies were also collected in Woman Creek at sites WO1 and WO3, but in considerably fewer numbers than in Rock Creek, while they were never collected in Walnut Creek. The only two species of stoneflies collected were *Capnura wanica* and *Malenka* sp. with *C. wanica* by far the more abundant. Both species are quite sensitive with tolerance values of 1 and 2, respectively. *Capnura wanica* adults emerge in late fall when they lay their eggs, which will hatch within 3 to 4 weeks (Hynes 1970); consequently, they were very numerous in the fall samples. The nymphs are long and thin and can burrow into the stream's hyporheic zone as surface flows diminish. They also have a resting (or dipause) stage that allows them to re-surface when flow conditions become more suitable. Such flow conditions appear to be fairly common in the Rock Creek drainage.

Both gastropods and bivalves (order Mollusca) were common in Rock Creek. *Physa* sp. was the predominant gastropod, as found in the other drainages, especially in 2001 (summer and fall); whereas, the bivalve *Pisidium* sp. (fingernail clam) was most abundant in 2002 (summer and fall). Both *Physa* sp. and *Pisidium* sp. were most abundant at site RC1 than at the other sites during the sampling period (Table 9).

Total macroinvertebrate densities were generally higher in Rock Creek than in the other two drainages with an overall mean density of 9,900 organisms/m^2. Site RC1M had the highest mean density at 14,466 organisms/m^2 at site RC1M, while the lowest mean density was 3,620 organisms/m^2 at site RC1. During the sampling period, total densities ranged from 1,476 organisms/m^2 at site RC1 in fall 2002, to 36,038 organisms/m^2 at site RC3 also in fall 2002 (Figure 2, Appendices D and E). Total numbers of taxa collected were also generally higher in Rock Creek than in the other drainages undoubtedly because of the comparatively greater diversity of habitat (Figure 2). Species richness ranged from 19 taxa at site RC1M in summer 2002, to 61 taxa at site RC2 in spring 2002. For all sites and seasons, species richness in the Rock Creek drainage ranged from 55 to 93 taxa. Again, the fewest number of taxa were collected during the summer 2002 sampling event likely due to the drought (Appendix C).

Overall, the mean species diversity for Rock Creek was higher than in the other drainages with a mean diversity of 3.52, with little variation among sites (3.33 to 3.63). Individual species diversity values were

moderately high and ranged from 1.92 at site RC2 in summer 2002, to 4.55 also at site RC2 in the spring 2002 (Figure 4). These relatively high species diversity values indicate a diverse macroinvertebrate community, although HBI and ICI values show the fauna consists mostly of hardy and tolerant organisms as found in the other drainages.

HBI values were generally high, as the species assemblage in Rock Creek was generally tolerant of environmental stresses. HBI values were generally similar to those in Woman Creek and Walnut Creek and ranged from 5.19 at site RC3 in spring 2002, to 9.47 at site RC2 in summer 2002 (Figure 4). The reason for the elevated HBI score at site RC2 in summer 2002 was the overwhelming abundance of tubificid worms (81.5%), which was also noted in Woman Creek at site WO1 in the spring 2002.

ICI scores also indicate the presence of a stressed macroinvertebrate community in the summer 2002 when 2 of the 17 sampling events had ICI scores in the *poor* category (2 and 6 at sites RC1M and RC2, respectively). Otherwise, scores on 13 occasions were rated as *fair* (20-34), and 2 were rated as *good* (40 and 38 at sites RC2 and RC3 in fall 2001) (Figure 5). According to mean ICI scores, the macroinvertebrate community in Rock Creek is probably the least stressed of the three drainages studied. The overall mean ICI score was 23.7 in Rock Creek with mean scores between 21.3 and 26.5 for individual sites.

3.3.4 Summary

The macroinvertebrate communities in streams draining Rocky Flats are generally similar to each other in that they were dominated by same groups of organisms namely, dipterans, oligochaetes, amphipods, molluscs, and a few mayflies. Within each of these groups, the species collected were also quite similar with a few exceptions. For example, the predominant mayflies in Walnut Creek were *Baetis tricaudatus* and *Callibaetis* sp., whereas in Woman Creek only *Caenis bajaensis* was dominant. In Rock Creek, both *C. bajaensis* and *Callibaetis* sp. were predominant as well as *Fallceon quilleri*. The caddisfly *Cheumatopsyche* sp. was only predominant at site WC3 where the flows are stable and effluent-dominated. The predominance of *Cheumatopsyche* sp. and other filter-feeding organisms at site WC3 will likely change after cessation of effluent discharges because of reduced stream flows and availability of suspended organic matter. Also of interest is that stoneflies were only collected at sites RC3, WO1, and WO3, and while not particularly abundant in Woman Creek, they were quite numerous at site RC3 on two occasions (fall 2001 and 2002). Overall, both total densities and taxa richness were highest in Rock Creek and lowest in Woman Creek. Mean species diversity values were also highest in Rock Creek

where the greatest habitat diversity is found. The macroinvertebrate community in Rock Creek is probably the least stressed of the three drainages studied. Whereas, the community in Woman Creek appeared to be the most stressed of the drainages because it had highest mean HBI value the lowest mean ICI scores (six scores were in the poor category during the study period), particularly at site WO3 where the lack of permanent water limits the establishment of the benthic community. This is also the case at sites WC4 and WC5 in Walnut Creek where the community is significantly affected by the interrupted flow regime.

3.3.5 Comparisons to Other Studies

Big Dry Creek Monitoring Program

In comparison to results of ongoing monitoring studies in Big Dry Creek and lower Walnut Creek, no major differences were apparent other than the presence of stoneflies in Rock and Woman Creeks. At the upper Big Dry Creek sites (bdc0.5, bdc1.0, bdc1.5, and bdc1.5C), densities and numbers of taxa were generally similar and the predominant groups were also dipterans and oligochaetes (Aquatics Associates, Inc. 2002). However, more species and numbers of mayflies and caddisflies and other insect taxa were present at the upper Big Dry Creek sites. The tolerant species of mayflies *Callibaetis* sp. and *Caenis bajaensis* that were predominant in Rocky Flats streams, were also present at these sites but in considerably fewer numbers. These species appear to have been replaced (in upper Big Dry Creek) by the more sensitive species *Baetis tricaudatus* and *Tricorythodes minutus.* Predominant species of chironomids were very similar to those found in Rocky Flats streams and included *Cricotopus* sp., *Dicrotendipes* sp., and *Micropsectra* sp. while the dominant black flies were also *Simulium vittatum* complex. Dominant molluscs were also physid snails and fingernail clams of the species *Pisidium* sp. Total densities in both upper Big Dry Creek and the Rocky Flats drainages varied widely but the range of densities (lows and highs) was generally lower in the Rocky Flats streams. Species richness was also generally similar, however, on certain occasions it was extremely variable in the Rocky Flats drainages as evidenced by the presence of only a few species and high densities at sites WC4 and WC5 in fall 2002. HBI values in the upper Big Dry Creek sites tended to be lower, while ICI scores were generally higher than those recorded for the Rocky Flats streams.

The predominant species found at the lower Walnut Creek sites (D2, W1, and W2) were similar to the streams at Rocky Flats, especially in Walnut Creek (WC1 through WC5) (Aquatics Associates, Inc. 2002). Total densities and taxa richness were also generally similar (except for the extreme case at sites

WC4 and WC5) to that found in lower Walnut Creek. Although HBI values for the Rocky Flats sites were slightly higher than for the lower Walnut Creek sites, the ICI scores were similar with the majority of scores in the *fair* category and only a few in the *good* and *poor* categories.

Macroinvertebrate communities in both upper Big Dry and lower Walnut Creeks were somewhat more abundant, rich, and sensitive than the communities found in the Rocky Flats drainages, which is most likely due to the more permanent flows and higher discharges. Overall, the Big Dry Creek macroinvertebrate study results suggest minimal water quality impacts associated with Site discharges.

Other Studies

In comparison to a previous aquatic macroinvertebrate study of Rocky Flats streams conducted by DOE (1992), the 2001-2002 sampling results were generally similar in terms of numbers of taxa, densities, and community structure. As concluded in the current study, the intermittent nature and lack of sustained stream flows was also implicated as the major limiting factor for sustaining healthy and balanced macroinvertebrate communities in lower Walnut Creek (sites D2, W1, and W2) and at one site at Rocky Flats (site D1) in a 1991 to 1994 study (Wright Water Engineers, Inc. 1995).

The 2001 and 2002 findings are also generally similar to macroinvertebrate communities in studies of other transitional foothills-plains and plains type streams. A study of three prairie streams in Nebraska were generally dominated by Oligochaeta, Baetidae and *Tricorythodes* mayflies, Hydropsychidae caddisflies, with Diptera consisting mainly of the midge subfamilies Chironomini and Orthocladiini and the black fly, *Simulium vittatum* (Harris et al. 2000). These same organisms were also predominant in a study of the plains section of the Cache la Poudre River in northern Colorado conducted by Colorado State University (Shieh et al. 1999) and in a study of several other Front Range streams (Zuellig 2001). Notably scarce in these studies was the amphipod *Hyalella azteca*, while they were relatively abundant in the Rocky Flats drainages. *Hyalella azteca,* however was found to be relatively abundant in Crow Creek, a stream in the plains of Wyoming, as were several of the same chironomid species found in the Rocky Flats drainages (Hubert 1996).

Reviews of related water quality studies did not indicate any discernable water quality impacts to the benthic macroinvertebrate communities in the Rocky Flats drainages (DOE 2003, Wright Water Engineers, Inc. 1995). In the 2002 ammonia study, concentrations of ammonia, nitrates, and nitrites were usually well below the State water quality criteria for these parameters (DOE 2003). Likewise, in the study by Wright Water Engineers, Inc. no nutrients and only a few metals were in exceedance of water quality standards (Wright Water Engineers, Inc. 1995). They concluded that the metals exceedances, which were in the ponds in Walnut Creek, were not sufficiently high to have caused any discernable effects on the macroinvertebrate communities.

4.0 RECOMMENDATIONS

1. Habitat assessment follow-up surveys, which are an integral part of the monitoring program, should be continued in the fall to document physical habitat changes. This is especially important considering the planned site closure activities such as wastewater treatment plant closure in September 2004, reduced discharges from the terminal ponds to Walnut Creek, removal of ponds in the Walnut and Woman Creek drainages, removal of buildings and impervious surfaces, etc.

2. While the 2001 fish sampling results provided an adequate baseline for existing conditions, fish monitoring should be continued in 2003 to determine the stability of fish communities in streams at the Site especially considering the 2002 drought. Subsequent fish surveys should also include sampling at site RC1M, which was added to the program in spring 2002, but has not yet been sampled. Future surveys on a 2-3 year basis should be sufficient to monitor fish populations and their stability in drainages at the Site.

3. Macroinvertebrate monitoring should be continued at all sites in 2003 with sampling frequency (spring, summer, and fall) and data collection/analysis methods consistent with previous years. In subsequent years, sampling frequency would be continued on an annual basis, but would be reduced to one or two seasonal events based on 2003 results.

4. The feasibility of macroinvertebrate collections using artificial substrates (Hester-Dendy) was evaluated. Based on site observations, this method was deemed inappropriate because of stream flow and depth limitations. Furthermore, multi-habitat kick net sampling is still the most appropriate method for these types of streams, and also the preferred methodology of the CDPHE-WQCD and other agencies.

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